INSIDE: Newsletter Digest

HIGH TECHNOLOGY BUSINESS

JULY 1988

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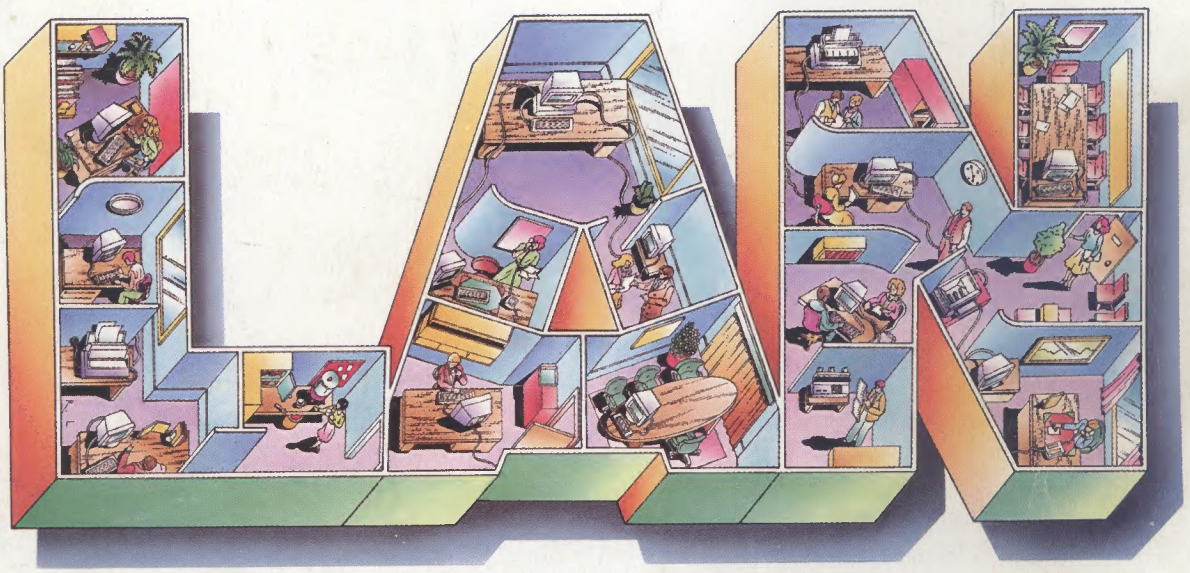

NETWORKS MAKE THE GRADE

■ ■ ■

Space Business on the Rise

Mini-supercomputer Makers Square Off

Buyouts Hit Defense Industry

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Astronomers can now image a patch of sky in seconds by employing tiny, super-chilled infrared detector arrays. Using previous arrays took astronomers 60 hours to construct infrared maps of the sky, by taking data one point at a time and re-aiming the telescope for each point. The two Hughes Aircraft Company-built arrays, now being used by national observatories, feature individual heat sensors that are up to one hundred times more sensitive than the detectors they replace. These arrays were originally designed by Hughes to help heat-seeking missiles find their targets and let surveillance satellites spot thermal sources on the ground.

A new printed wiring board (PWB) significantly reduces the manufacturing cost of large backplanes, or motherboards, while improving producibility, performance, and reliability of the computers they help operate. Developed by Hughes for military computer applications, the 18-layer PWB contains 7,500 fewer wires than the one it is designed to replace, and may be the most complex such board ever manufactured. The multilayer design of the new board minimizes the number of machine-wrapped wires, requiring only 2,500 such wires, compared to 10,000 on present PWBs, thus greatly simplifying assembly and inspection.

A new Probeye® thermal video system achieves true portability by using thermoelectric cooling, which eliminates the need for gas or liquid nitrogen supplies. Using rechargeable batteries, the Probeye Model 7100, built by Hughes, is a complete thermography system that provides a visual display of the temperature distribution of a scene being viewed by the infrared imager. The Model 7100 features enhanced capabilities to provide more information and a wider range of applications than previous thermal video systems, and provides a display resolution of 240 infrared scan lines—four times greater than previous Probeye viewers.

A special space-based imaging sensor uses microwave energy to determine weather conditions with more accuracy than is possible with current systems. Designated SSMI, the Hughes-built sensor is flying aboard a U.S. Air Force weather satellite in a 527-mile-high orbit. Current weather satellites use visible and infrared images to record images of the tops of clouds to chart weather patterns. SSMI, using microwave energy, can "see" into and through clouds, permitting observation of the underlying rain structure and possible estimation of the intensity of the storm. By knowing the intensity, forecasters can more accurately predict storms that may become hurricanes and typhoons.

Hughes Research Laboratories seeks a select number of scientists for advanced research in physics, chemistry and electronics. Disciplines include: AI knowledge-based systems, planning, and computer vision; space plasma sources; pulsed power switches; free electron lasers; applications of focused ion beams; electron beam testing; liquid-crystal materials and displays; nonlinear optics and phase conjugation; submicron microelectronics; computer architectures for image and signal processors; GaAs microwave devices and IC technology; and optoelectronic devices. Send your resume to: Professional Staffing, Hughes Aircraft Company-Research Laboratories, Dept. S2, 3011 Malibu Canyon Road, Malibu, CA 90265. Equal opportunity employer. Proof of U.S. citizenship required for some positions.

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JULY 1988
VOL. 8, NO. 7

Cover illustration by Roger Leyonmark

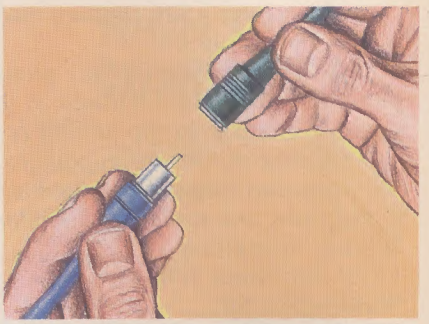
HIGH TECHNOLOGY BUSINESS

FEATURES

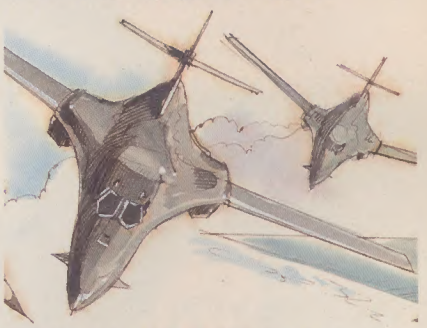
COLUMNS

MARKETWATCH

DEPARTMENTS



Networks poised to plug into profits, p. 20.



Buyouts soar in defense electronics, p. 30.

Suppliers square off over mini-supercomputers, p. 48.

HIGH TECHNOLOGY BUSINESS

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Communication Gets Comfortable

HAVE YOU EVER noticed that the communications revolution seems to work better on a long-distance basis than on a short-distance one? We accept without question that an airline can book a complicated set of reservations in, say, New York, and that we will end up having available space—and even pre-assigned seats—when we reach Boston, Chicago, Los Angeles, or Atlanta. But we also accept the fact that someone a couple of offices away can only be kept informed of our itinerary through a series of memos, calendar entries, and slips of paper that tend to get lost 30 seconds before you need them.

Connectivity within the office has been slow in coming. One major reason is personal, involving the comfort provided by human contact in the office and the ease of working with pieces of paper and other things that you can carry around, rather than with bits and bytes and video display terminals. But the discomfort of electronic communication is decreasing, and the next generation of business leaders will probably feel just as good about electronic communication as about the non-electronic kind—that is, assuming new communication is as simple and at least as efficient as old-style communication.

That question—of simplicity and efficiency—has been the second major problem facing the electronic office. This problem is finally being addressed in a way that will make local-area networks (LANs) worth investing in and using. Our in-depth study of LANs (p. 20) shows why the time for network communication may finally be at hand.

In the long run, we will have to rethink our relationship with the workplace before we truly accept networks and other forms of high technology. A significant barrier to all success in high-technology business is the need to change the attitude of the marketplace, often in ways that require people to reexamine who they are and how they relate to their environment. We look at the problems posed by the need to change people's way of viewing the world in our Books column on p. 18. This new monthly column will offer reviews, comments, and sometimes, as is the case this month, essays inspired by recently published books that raise issues of importance to high-technology businesses.

Also this month, we look at the consolidation of power in the defense-electronics industry (p. 30), the face-off in the mini-supercomputer market (p. 48), and the possibilities for profit from manufacturing in space (p. 43). And we have further expanded our Newsletter Digest (p. 55) to give you even more in-depth coverage of high-technology developments from industry-specific publications.

Mark Estren

Biotech Conditions

THE APRIL ARTICLE "Cash Crisis Creates Biotech Alliances" makes our agreement with Merck sound like a distress sale of our technology. However, this agreement was completed long before the October 19th market crash, during a period of intense financing activity.

It would be unreasonable for a small company at Repligen's stage of development to attempt to develop and market an AIDS vaccine entirely on its own under any circumstances. Our partnership with Merck, the world's leader in vaccine development, was considered a major achievement for Repligen by the financial markets, resulting in a significant increase in our valuation. Also, our collaboration with Merck gives us both a royalty relationship and a manufacturing agreement under which we have the option to manufacture all AIDS vaccine products sold by Merck.

These facts do not describe a company "forced to accept less advantageous conditions" due to stock-market weaknesses. We could have hoped for no better than a relationship with Merck.

Thomas H. Fraser, Ph.D.
Executive Vice President
Repligen Corp.
Cambridge, Massachusetts

Editor's note: *The fact that Repligen "could have hoped for no better than a relationship with Merck" underscores our major premise—that now, more than ever, small biotechnology companies must rely on larger companies for funding.*

High-Definition TV

CONTRARY TO a comment attributed to me in "TV: The Push for a Sharper Picture" in your April issue, I do not believe any of the proposed advanced television systems to be superior to any other. The tests that may lead the industry and the FCC to make a determination in favor of a particular system or technology have yet to be conducted.

Thomas B. Keller
Chief Scientist
National Assoc. of Broadcasters
Washington, D.C.

A Point of Law

AS PATENT, trademark, and copyright attorneys, we wish to take issue with one point of law made in the otherwise fine column "Let the Buyer Beware—Technology Rights Are Key to Takeovers" (April, p. 17). The author, David Hammer, urges a potential buyer of a high-technology company to ascertain whether the company has "protected its rights—preferably by patenting hardware and copyrighting written processes, know-how, and software."

Innovative processes and know-how, however, rarely are best protected by copyrights. Processes and know-how, like hardware, generally should be protected either by seeking patents or by taking the appropriate steps to maintain them as trade secrets. Regarding software, the author is correct that copyright protection typically should be sought, but trade secrets and, in certain circumstances, patent protection should also be considered.

John D. Vandenberg
Henry D. Coleman
DeRosa, Vandenberg & Coleman
New York, New York

David Hammer responds: *The phrase "or licensing," which originally appeared after the word "copyrighting" in the quoted passage, was inadvertently deleted in the editorial process; licensing not only written processes and know-how but also software is indeed the most common method chosen to maintain these forms of property as trade secrets. Though patent protection is available for written processes, know-how, and, in some limited instances, software, this form of protection is generally more expensive and time consuming to obtain, and is therefore a less common form of protection than licensing.*

The Integrated Solution

THE FEATURE "Designware Leader Faces New Threat" in the April issue correctly identified the trend towards integrated systems in the computer-aided software engineering (CASE) field, but I must disagree with its suggestion that the "integrated solution" is "something new in the CASE arena." The engineering community has long recognized the advantages of using an integrated CASE environment to support more than one phase or activity in software development. In contrast to the tools for commercial applications highlighted in the article, the software-engineering environment EPOS, used in European aerospace, defense, and engineering companies since 1982, and in U.S. companies since 1986, has been providing support based on an integrated database for years.

Peter Lempp
Manager, Software Engineering
Software Products & Services Inc.
New York, New York

Apple's Prospects

I WAS TAKEN aback by Andrew Seybold's hype of the prospects of the Apple Macintosh in the corporate market ("Apple's Corporate Image," April, p. 13). In desktop publishing the Macintosh does have the lead, because of ease of use. However, in computer-aided design (CAD), there is no major software written for the Macintosh in widespread use. There are several for the IBM PC. Also, Lotus 1-2-3, one of the most powerful and popular programs, is written for the IBM PC.

Recent advances in transferring Macintosh file formats to PCs and vice versa do not mean that Mac users can "take advantage of a larger selection of software than ever before available," as Mr. Seybold asserts. It does mean they can access the seemingly limitless information stored in the gargantuan number of IBM PCs, minicomputers, and mainframes that already exist in numbers far in excess of Macintosh market performance to date.

Howard Dinin
Cambridge, Massachusetts

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Ultrasound Becomes Ultraportable

A BOSTON doctor recently helped save a patient's life by using a hand-held ultrasound scanner to diagnose a rupturing aorta in two minutes flat.

Dr. Stephen Gerzof, chief of body computed tomography at the Veterans Administration Hospital, used Damon Corp.'s ScanMate, a five-pound alternative to the massive ultrasound scanners that produce images of soft tissues and organs without using radiation. Unlike its larger cousins, the ScanMate needs little or no setup time, runs off a battery, and has a pen-like probe to scan patients too sick to be moved to a larger machine.

Portable scanners, including cart-mounted versions, will grab 25 percent of the ultrasound-scanning market this year, according to Damon, which is based in Needham Heights, Mass. The $900-million market for diagnostic ultrasound machines will grow about 15 percent this year, predicts Paul Brown, an analyst at Hambrecht & Quist.

The $9,000 ScanMate is operating in hospitals, emergency rooms, doctor's offices, and radiology departments to diagnose problems such as kidney or gall stones, aneurysms, and heart abnormalities. Each scan takes less than ten minutes. The device can also examine babies still in the womb and help guide a needle when taking a biopsy.

DAMON CORPORATION

Damon's hand-held ultrasound scanner competes with much larger units.

Damon markets the device for Pittsburgh's Dymax Corp., which developed and builds the patented scanner. The company won't reveal its sales projections, but says it has sold hundreds of the hand-held units.

Interactive TV Enters the Home

AN INTERACTIVE system that lets viewers communicate with their TV sets is designed to offer consumers a new source of entertainment and boost revenue for businesses and advertisers.

The system, from ACTV Inc., combines graphics, sound, and the company's View-Master video system. Using a four-button keypad, viewers can personalize special TV shows by answering questions posed by an announcer, or by choosing among several potential outcomes. TV watchers will be able to play Blackjack with an expert dealer, create their own exercise programs, control camera angles during sporting events, compete in game shows, or learn lessons tailored to their interests.

ACTV, based in Port Washington, N.Y., says its patented system supports thousands of possible outcomes for each program. The system transmits its signals in the vertical blanking interval that separates television picture frames.

The first programs will appear next year on the Groupe Videotron cable system in Montreal (which has been testing the system for two years) and on undisclosed U.S. cable systems, according to Michael Freeman, inventor of the system and president and CEO of ACTV. Freeman hopes to start with

HOWTEK INC.

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can program the machine to require passwords as well.

The $2,750 machine measures 11×11×3½ inches, weighs nine pounds, and can work with IBM PCs. Linus Technologies introduced the Write-Top this spring and hopes to sell 4,000 of the patented units this year, mainly through resellers.

FLEISHMAN HILLARD INC.

This portable computer can learn to recognize handwriting.

of Danvers, Mass., is testing a probe that detects gum disease at a very early stage. A disposable tip on the probe measures gum temperature; higher temperatures indicate the presence of bacteria, even before a person feels any irritation. The device could also help monitor gum-disease treatment.

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30,000 to 40,000 subscribers and expects to reach a million viewers by 1995.

Freeman says the new system will open a door for advertisers who want to gear their campaigns to particular audiences. For example, female viewers could see makeup commercials while male viewers watch ads for aftershave.

Treatments for Gum Disease

SEVERAL companies are working on products that aim to alleviate gum disease.

Researchers at Vipont Research Laboratories Inc. of Fort Collins, Colo., are developing a new treatment that could replace painful and expensive periodontal surgery. The treatment uses a polymer that contains the compound sanguinarine, which is extracted from the bloodroot plant. Vipont's treatment will cost about $150, compared to about $800 for surgical treatments.

Vipont also sells mouthwash and toothpaste that contain sanguinarine to help prevent bacteria from accumulating in the mouth. Sanguinarine could also fight bacteria that has already infiltrated the gums, says president G. Lee Southard. Vipont expects to begin testing the polymer, which disintegrates harmlessly within 10 days, later this year.

Meanwhile, Abiomed Inc. of Danvers, Mass., is testing a probe that detects gum disease at a very early stage. A disposable tip on the probe measures gum temperature; higher temperatures indicate the presence of bacteria, even before a person feels any irritation. The device could also help monitor gum-disease treatment.

Color Comes to Office Documents

IMPROVED technology and lower prices are helping make color documents commonplace in the office. By 1991, the market for color printers and plotters will more than triple, reaching $4.7 billion, compared to the 1986 level of $1.5 billion, according to a study by consultant CAP International Inc.

Unit sales of all color-output technologies should increase from 539,000 in 1986 to 2.1 million in 1991, according to the CAP study. These technologies include photographic, electro-photographic, and electrostatic processes; thermal-transfer, ink-jet, and dot-matrix printers; and pen plotters.

Last year, for the first time, color computer monitors accounted for more than half of the market, says Mike Helsel, marketing manager for business graphics at CalComp of Anaheim, Calif. CalComp, a Lockheed subsidiary, has extended its expertise in color computer graphics for scientists into color-based products for the office environment.

HOWTEK INC.

Howtek's color scanning and printing system produces high-quality images.

Color copiers are also getting cheaper, and are starting to enter the general business market. Prices for most color copiers have fallen from more than $50,000 to less than $40,000. Xerox sells a model for $39,000, and Canon's lowest priced color copier is $37,000.

Howtek Inc. of Hudson, N.H., is one of only a few companies that make color scanners. Vice president of marketing Ray Roque says only scanners can replace artificially generated color images with the photographic-quality images people have come to expect. Roque predicts that by 1990, about half of all color presentation and graphics systems will include a color scanner.

Handwriting on The Screen

MOST RESEARCH on computer interfaces has focused on voice recognition and synthesis, but a portable computer called the Write-Top is designed to recognize handwriting. Linus Technologies Inc. of Reston, Va., plans to sell the device to banks, retailers, lawyers, and health-care professionals—anyone who fills in forms by hand.

FLEISHMAN HILLARD INC.

This portable computer can learn to recognize handwriting.

The computer has a pressure-sensitive touchscreen that resembles a clipboard. Users write on the screen with an attached stylus, an ordinary mechanical pencil. Built-in software reads the pencil's "electronic ink," converts it to pixels at a resolution of 640×200, and then to ASCII characters that can be read by other computers.

The system "learns" an individual's handwriting and signature and responds only to handwriting it knows. For additional security, users can program the machine to require passwords as well.

The $2,750 machine measures 11×11×3½ inches, weighs nine pounds, and can work with IBM PCs. Linus Technologies introduced the Write-Top this spring and hopes to sell 4,000 of the patented units this year, mainly through resellers.

High-Tech Winemaking

THE ANCIENT art of winemaking is generally considered a bastion of low technology. However, two California wineries are taking advantage of advanced technology to imitate or replace time-honored manual methods.

SONOMA-CUTRER VINEYARDS

Vintners blend art and science.

Sonoma-Cutrer, a winery in Windsor, Calif., uses a grape press that duplicates the pressure and treading action of human feet. Most mechanical presses crush the seeds and stems as well as the grapes, introducing bitterness to the wine. Sonoma-Cutrer has equipped its tank press with a special membrane that has a supple feel, like the foot of a seasoned grape-stomper.

Sonoma-Cutrer has also modified its presses to inject nitrogen, which displaces the oxygen that can alter the flavor of the juice. In addition, the winery uses a prototype bottling machine that fills the wine bottles from the bottom. This technique eliminates the agitation and oxygen pickup associated with conventional methods that fill the bottles from the top.

At Domaine Chandon in California's Napa Valley, technology comes into play once the wine is in the bottle. Riddling—the process of incrementally turning bottles of champagne and sparkling wine to maneuver the sediment into the neck of the bottle for easy removal—can be tedious and costly. That's why Domaine Chandon has developed a mechanical riddler dubbed the VLM, for "very large machine." The 17-foot riddler holds about 4,000 bottles; a computer tells it when and how far to turn each one. Using the VLM has cut the winery's riddling work cycle by about 50 percent and saves Domaine Chandon $280,000 a year.

New Drugs From An Old Source

PLANTS HAVE been a source of healing drugs for millenia, and researchers are using new screening and cell-culturing techniques to isolate cells instead of the entire plant. This will make it easier to isolate plant compounds that look promising as treatments for such diseases as cancer, AIDS, and Alzheimer's. In addition, advances in genetic engineering are making it possible to manipulate individual cells to enhance the potency and production of drugs derived from plants.

Researchers are paying particular attention to exotic plants, because many species may become extinct as remote jungles and rain forests shrink. According to a report by the Technology Management Group, the National Cancer Institute is screening 10,000 plant substances retrieved from rain forests to test their effectiveness against cancer cells and the AIDS virus.

More mundane plants are also under scrutiny. Xoma Corp. of Berkeley, Calif., has used a toxin from the castor bean to produce antibodies against metastatic melanoma, a form of skin cancer, and has managed to stabilize and shrink some tumors.

According to the Technology Management Group's report, at least 22 research institutes and about 75 U.S. companies are involved in producing and developing pharmaceutical products based on plant compounds.

HAL MAYFORTH

Unix Goes Graphic

TAKING A CUE from a trend in personal-computer software, Unix, the increasingly popular operating system used in engineering minicomputers, has adopted a graphic-based user interface. The move could make Unix a standard in the office as well as in scientific and engineering labs.

Engineers don't seem to mind Unix's difficult user interface. But the easier-to-use graphic version, called Open Look, could be a hit in offices by making computer programs easier to work with and letting businesses create cheap computer networks.

Like the Apple Macintosh, the Open Look interface divides the screen into flexible "windows." Users choose functions by "pointing" with the screen cursor. Because many windows can be opened at once, users can run several programs simultaneously.

Despite Unix's power, a lack of compatible personal-computer office software has kept the operating system out of the business world. But two key developers of such software—Ashton-Tate of Irvine, Calif., and Lotus Development of Waltham, Mass.—have hailed Unix's new look and dropped hints about plans to create Unix software after the Open Look specifications come out later this year.

AT&T, the creator of Unix, worked with fast-rising workstation maker Sun Microsystems of Mountain View, Calif., to create the graphic version of Unix. AT&T recently agreed to buy 20 percent of Sun; both companies are pushing Unix to boost computer sales.

Arch rivals IBM and Microsoft Corp. of Redmond, Wash., are developing a graphic interface for their OS/2 personal-computer operating system. However, OS/2 still won't be able to match Unix's ability to build low-cost office networks by connecting inexpensive terminals to IBM-compatible personal computers.

Security by Fingerprint

SMALLER, faster, and less expensive fingerprint scanners are enhancing data security for business computer users. Such devices have been used mainly by law-enforcement and defense officials to keep unauthorized people out of restricted areas or control access to sensitive data. But a rash of new products aim to help businesses keep their computer data private. Bankers, doctors, accounting firms, and educational institutions can now get affordable protection for the information stored on their personal computers.

Three companies have just introduced low-priced fingerprint scanners that verify a person's identity in just a few seconds. Identix Inc. of Palo Alto, Calif., makes the TouchSafe, a device about as big as a computer mouse. An internal model costs $1,795; a stand-alone version is $1,895. Thumbscan Inc. of Oakbrook Terrace, Ill., offers the $995 Thumbscan, which is about as big as a personal-computer modem, and Fingermatrix Inc. of North White Plains, N.J., sells the $1,495 Ridge Reader Mint 11, which works in personal-computer networks.

IDENTIX INC.

Fingerprint scanners let only authorized users log on to a computer.

All three systems combine hardware and software and include an "audit trail" feature that keeps tabs on who tries to use the system. The devices can also alert supervisors if unauthorized users attempt to log on.

Such scanners are part of the "biometric-access control" market, which will total about $30 million to $35 million this year, estimates Ken Bosomworth of International Resource Development Corp. Fingerprint scanners represent about two-thirds of the market. Other biometric security technologies include voice recognition, eye scanning, hand geometry, signature verification, and keystroke dynamics. If the industry can continue to make its products smaller and cheaper, Bosomworth says, the market for fingerprint scanners could grow 50 percent a year.

ALSO WORTH NOTING

CAMVAC INTERNATIONAL INC.

Metalized-film packaging can double the shelf life of food products.

■ A new type of packaging promises to double the shelf life of foods such as vacuum-packed coffee and candies. The material, developed by Camvac Ltd. of Norwich, England, uses layers of metalized film so that defects in one layer won't let moisture or oxygen penetrate a sealed package. The film is also flexible, and thus less likely to rip than aluminum foil when applied to pouches or boxes. Camvac currently uses the material to package food products, but is considering industrial uses such as packaging delicate engineering components and photographic film.

■ A microsensor may soon help detect smoke and other hazardous fumes for those whose sense of smell has deteriorated. Developed at Sandia National Labs in Albuquerque, N.M., the rugged sensor is about the size of an eraser. Robert Hughes, the primary developer of the device, says people could wear it on their wrist to sound an alarm if certain odors are present. The sensor uses very little power and could run indefinitely off a tiny watch battery. Hughes is refining the technology to detect a variety of odors, from spoiled meat to gas leaks, as well as the early stages of burning that do not produce smoke.

■ Consider donating outmoded computer equipment to Global Technology Foundation, a nonprofit group that recycles used technology to developing countries. The foundation needs such items as computers, manuals, software, telephones, and scientific equipment. Companies can take a tax deduction of the equipment's book value and reap the public-relations value of sharing the technological wealth, says Philip Friedman, executive director of the group, which is based in Boulder, Colo. Individuals who donate equipment can deduct its fair market value. For more information, telephone (303) 440-1115.

■ A new computer board lets desktop publishers grab images from video sources. The $595 Laser Board, developed by User Friendly Operating Systems Inc. of East Rochester, N.Y., can use images from video cameras, cassettes, disks, and computer-aided design and drafting systems. The board works with desktop-publishing systems running on the IBM PC or compatible computers. It prints the images on Xerox laser printers; versions designed to work with printers manufactured by Hewlett-Packard and Canon will be available soon.

Lotus at Risk

SPREADSHEET LEADER GUARDS ITS TURF

■ **By Clinton Wilder**

IN THE VOLATILE world of personal-computer software, one hot program can turn a startup into an industry leader. But what happens when the product ages, and the company's attempts to diversify fail?

For Lotus Development Corp. and its 1-2-3 electronic spreadsheet, the answer is nothing—yet. Lotus still controls 75 percent of the worldwide spreadsheet market and shipped more than a million copies of its 1-2-3 program last year. Lotus' sales grew 40 percent in 1987 to nearly $400 million, and profits vaulted 49 percent to $72 million.

But all is not sweet at the spreadsheet leader. Once the largest independent personal-computer software company, Lotus has lost the lead to arch-rival Microsoft Corp., whose MS-DOS and OS/2 operating systems guarantee revenue from virtually every sale of an IBM-compatible microcomputer. And the gap is growing. Extensive product diversification helped Microsoft boost first-quarter 1988 revenue and earnings at rates Lotus couldn't match.

Lotus, on the other hand, remains essentially a one-product company, and 1-2-3 has met increasing competition from Microsoft's Excel and products from newer competitors such as Borland International. Excel has a leg up because it supports Windows, the graphic interface that Microsoft built into IBM's new OS/2 operating system.

Lotus' attempts to broaden its product line have met mixed results. The company's foray into the Apple Macintosh market with a program called Jazz was a virtual disaster. Symphony, Lotus' integrated software package for IBM PCs, has done better, but not as well as originally expected. Lotus' most successful new products have been those that work with or enhance 1-2-3.

However, don't count Lotus out. "Wall Street has this theory that software companies have to diversify. But every time they do, they lose their focus and get into financial trouble," says Jeffrey Tarter, editor of *Softletter*, an industry newsletter. "Lotus always gets asked, 'What if 1-2-3 goes away?' That's ridiculous. It's not a hula hoop."

TOM LULEVITCH

Indeed not; 1-2-3 remains a staple for anyone who uses numbers in business. Lotus' challenge is to maintain that success as a much larger and very different company. Founder and technical wizard Mitch Kapor, whose interest in transcendental meditation inspired the company name, has moved on to a new venture and left Jim Manzi, a hard-nosed manager, at the helm. Manzi's task is to maintain 1-2-3's lead over Excel, Borland's Quattro (priced about $200 less than 1-2-3), and the many Lotus clones, two of which have attracted Lotus lawsuits for alleged infringement of 1-2-3's copyright.

"Because Lotus had the lion's share of the market, it will always be in the defensive position," says First Boston software analyst Bruce Johnston.

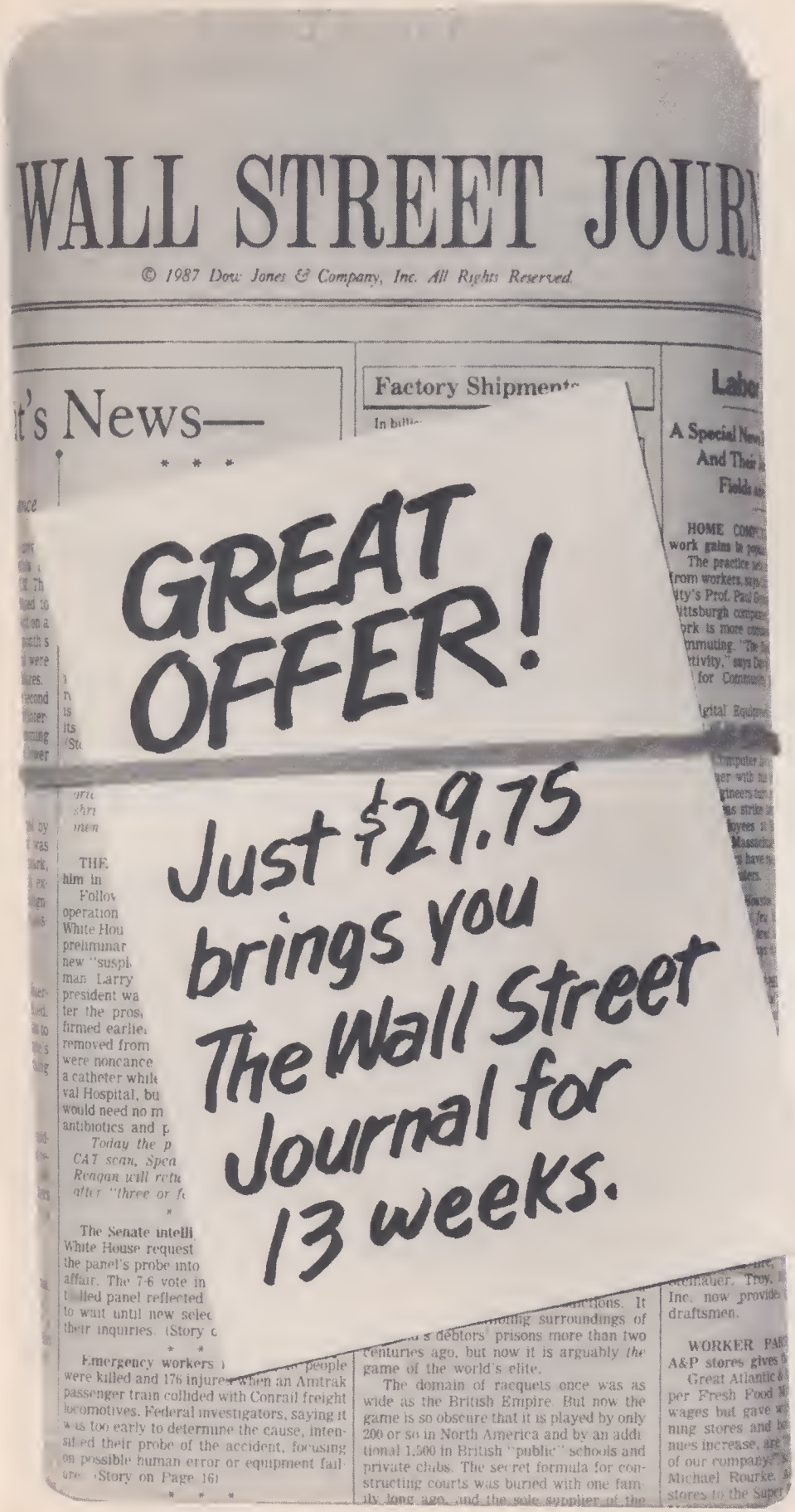
In March, the news that 1-2-3's long-awaited upgrade, Release 3, would be six months late sent Lotus stock into a nosedive. "It came at a time when Lotus faced the first real competitive threats it's seen in several years," says Johnston. "That makes people nervous." The Securities and Exchange Commission was nervous enough to investigate major stock sales by top Lotus executives several weeks before the announcement, but the company strongly denies any connection between the two events.

Delays of major products are not uncommon in the software industry, but Release 3 is the first upgrade of 1-2-3 in more than two years. Lotus hopes the delay will prove to be more a short-term embarrassment than a long-term strategic disaster, and 1-2-3's huge installed base and user loyalty, coupled with Release 3's promised features, should keep defections to a minimum.

Still, one-product companies cannot let their flagships drift. Micropro International Corp. of San Rafael, Calif., whose WordStar program ruled the word-processing market during the personal-computer boom of the early 1980s, learned this lesson the hard way. Micropro couldn't keep WordStar ahead of the technology curve, and the company is now under new management and struggling to sustain any profits at all.

To stay successful, analysts say, Lotus must keep improving 1-2-3 while preserving product loyalty. The industry trend toward user-friendly interfaces like that of Apple's Macintosh will be a key test. If Lotus can give that kind of graphic ease to new updates of 1-2-3, yet maintain ties to previous versions, the company should keep milking its cash cow for a long time. ■

Clinton Wilder is a senior editor and columnist for the computer industry section of Computerworld.



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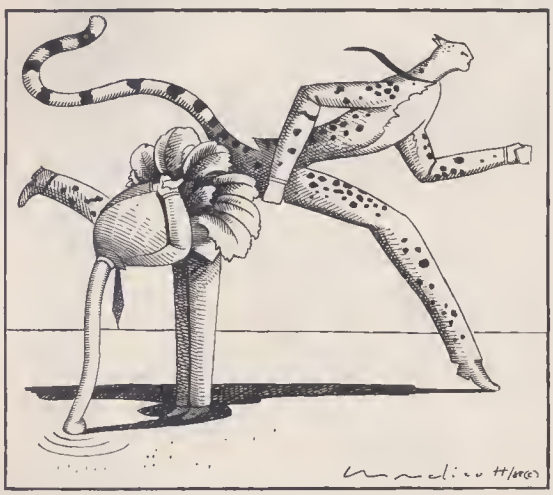
Superconductor Strides

JAPAN SEEMS POISED TO TAKE THE LEAD

■ **By Robert Chapman Wood**

FOR THE FIRST time since Japan's economy drew abreast of the West's in the 1970s, Japan has a radically new technology to exploit with its systematic approach to innovation. Today, the Japanese seem well positioned to do to the U.S. scientific community what they did to U.S. manufacturers in the late 1970s—inflict a blow so dramatic that it will force a bitter rethinking of the American way of doing business.

Japan is now introducing at least three or four times more superconductivity products than is the United States. The Japanese companies involved in superconductors read as a *Who's Who* of Japanese industry, says Stanley R. Rich, who publishes *The Cambridge Report on Superconductivity* newsletter.



JAMES ENDICOTT

Hitachi Ltd., for instance, has announced several superconductor devices, including an optical switch that adjusts electric current depending on the amount of light in the vicinity. The company claims the switch handles five times more current than do conventional devices. Hitachi has also announced an extremely sensitive magnetic-field detector called a "squid" (superconducting quantum interference device) that doctors can use to detect tumors and other abnormalities in the body.

Japanese computer manufacturers have revitalized research into Josephson junctions—superconductor-based computer-memory devices. Before the discovery of high-temperature superconductors, work on Josephson junctions had virtually halted in the United States, but research continued in Japan. According to Japanese press reports, Nippon Electric plans to build a supercomputer using Josephson-junction technology that would reduce size and power consumption by 90 percent.

Sanyo Electric and Sumitomo Electric, two diversified manufacturers, and Fujikura Electric, a major electric-cable producer, have all announced commercial sale of superconducting wire. Only relatively small outfits sell such wire in the United States.

Raw materials for superconducting applications are selling far better in Japan than on this side of the Pacific. For example, as early as last December, Hayashi Chemical Industries Co. was selling a metric ton per month of a bismuth-based material used to manufacture high-temperature superconductors. That's at least four or five times the sales of the largest U.S. producers of comparable materials, says Rich.

Other major Japanese companies that have announced superconductivity products include Fujitsu, Kyocera, Matsushita Electric Industrial, Mitsui Mining and Smelting, Nippon Chemical Industries, Sharp, and Toshiba Electric.

In the United States, most major superconductivity products have come from smaller companies. Larger U.S. companies such as IBM, GE, and Du Pont also have significant superconductivity programs, but none has announced products comparable to those of the major Japanese companies, according to Rich. A recent survey by the U.S. Office of Technology Assessment reached similar conclusions.

One reason the Japanese have become so heavily involved is that they anticipate a far larger market. The *Nihon Keizai Shimbun*, Japan's equivalent of the *Wall Street Journal*, reports that Japanese estimates of the potential world market for superconductors in the year 2000 run about $20 billion to $40 billion. Rich says that U.S. estimates of the market fall in the $1.5-billion range.

Whatever the eventual size of the market, a dramatic defeat for the U.S. superconductor industry would be a serious reflection on American methods of managing technology. Until about 1980, Japan made little effort to produce new technology; most of its successes—cars, VCRs, laser printers, and robotics—are basically refinements of Western technology. But in the late 1970s, Japan began to focus on developing new technology. Industry and government tried to demystify the research-and-development process. They also kept track of worldwide developments, a strategy that has paid off. The discoverers of high-temperature superconductors, employed at an IBM lab in Switzerland, had arranged to publish their results in a relatively obscure German journal. Japanese monitoring systems picked up the publication immediately, and the work was replicated in Japan even before it was known throughout IBM.

Whether or not Japan succeeds in systematizing innovation, one thing is certain: the rest of the world will soon be reading more about Japanese superconductor innovations. ■

Robert Chapman Wood is an analyst and business consultant who specializes in technology and the Japanese economy.

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last fiscal year	$.55
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next fiscal year	$1.90
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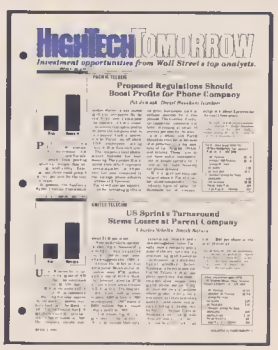
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Eyes in the Sky

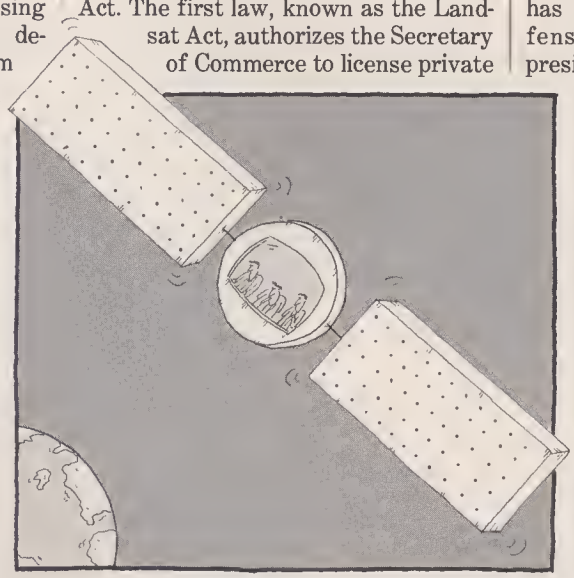
GOVERNMENT EASES GRIP ON SATELLITES

■ By Robert J. Aamoth

THE GENERAL public may soon gain access to the satellite remote-sensing technology that governments have been using to keep tabs on earthly events.

The fate of this new industry—using high-resolution cameras to take detailed photographs of the earth from orbiting satellites—depends on the outcome of several legal questions, including whether the First Amendment applies in space and how much the government can control technology in the name of national security.

Satellite remote sensing is that rarest of commodities—a source of new information. The Commerce Department estimates that the remote-sensing market will gross $6 billion annually by the year 2000, compared to an estimated $100 million in 1985.



MARK KSENIAK

As the technology has improved, the push for government approval has intensified. In the early 1970s, the first Landsat satellites showed objects 80 meters across, and by the 1980s they could pick out features as small as 30 meters. In February 1986, the French launched a satellite with 10-meter resolution. A number of parties are now developing satellites with 5-meter resolution, and U.S. intelligence satellites reportedly have a resolution of a few inches.

The news media, led by the Radio-Television News Directors Association, have been trying to establish remote-sensing systems free from government censorship. The potential value of such systems is enormous. For example, during the Chernobyl nuclear reactor accident in April 1986, these satellites provided the only independent source of information available to the Western world. Since then, the news media have taken steps to integrate remote sensing into daily news-gathering operations.

So far, however, the U.S. government has sent out mixed messages concerning private use of this technology. In 1984, Congress adopted the Land Remote-Sensing Commercialization Act and the Commercial Space Launch Act. The first law, known as the Landsat Act, authorizes the Secretary of Commerce to license private parties to establish remote-sensing satellites; the second law lets the Secretary of Transportation license private launches of satellites.

The stumbling block is a set of rules issued on behalf of the Department of Commerce by the National Oceanic and Atmospheric Administration (NOAA) last July. Although NOAA officials support the news media's efforts to establish a competitive presence in remote sensing, NOAA's rules, in the name of "national security" and "international obligations," give the State and Defense Departments virtually unbridled discretion to impose restrictions on a remote-sensing licensee. Standing behind these rules was a classified 1978 executive order from President Carter, which prohibited civilian satellites with a resolution of less than 10 meters.

These rules have discouraged private investment in high-resolution satellites, and the news media believe NOAA's rules violate the First Amendment.

A break in the clouds occurred last January, in the form of President Reagan's National Space Policy. Though much of this policy remains classified, it has been reported that, over the Defense Department's objections, the president abolished President Carter's 10-meter barrier. The policy affirms that it is in the national interest for the private sector to develop remote-sensing capability. In April, media organizations seized this opportunity to seek more hospitable rules from NOAA regarding remote-sensing systems.

But such systems must still prove themselves in the market. Low-resolution satellite systems have required government subsidies, leading some observers to infer that high-resolution satellites will not make money either. Increasingly, however, the industry is recognizing that high-resolution systems that can detect objects of five meters or less will broaden demand. The news media represent the most significant new market, but one entrepreneur has reportedly grossed more than $1 million selling posters of a satellite view of Los Angeles.

Remote sensing is a market waiting to be tapped. The news media have expressed enormous interest but have not made major investments, and the existing remote-sensing industry has remained cautious while the media debate a financial commitment. But as federal regulations relax, the question will change from whether a private remote-sensing satellite will be launched, to who will do it and when. ■

Robert J. Aamoth, an attorney with the Washington law firm of Pierson, Ball & Dowd, is an expert in satellite regulation and the commercialization of space.

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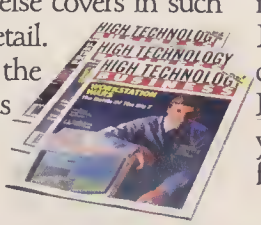

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Escaping the Paradigm

INNOVATIONS DEMAND A NEW WORLDVIEW

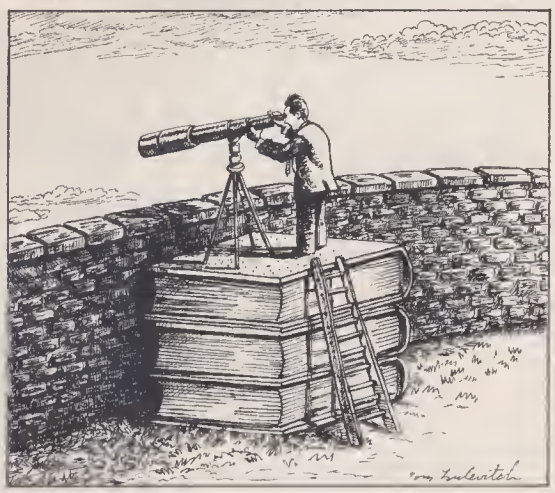
■ **By Mark J. Estren**

The Constraints of Corporate Tradition
by Alan M. Kantrow.
Harper & Row. 236 pages. $19.95.

The Creative Corporation
by Karl Albrecht with Steven Albrecht.
Dow Jones-Irwin. 228 pages. $20.95

One of the biggest barriers to success in the high-tech marketplace is not products but paradigms, or ways of seeing the world. These conceptual structures, within which new developments can be analyzed and understood, help us process information much more quickly and efficiently—so long as the information fits the paradigm and does not challenge the assumptions on which it is founded.

Therein lies the problem for the high-technology community. Innovations often require us to rethink the way we view the world, to reconsider paradigms or develop new ones—a monumental task for individuals and companies alike.



TOM LULEVITCH

It is easy, using 20/20 hindsight, to marvel at the apparent ignorance of historical business decisions, such as Western Union's handling of the Bell telephone system in 1879. In this case, which is well presented by Alan Kantrow in *The Constraints of Corporate Tradition*, Western Union confirmed the fledgling Bell group's control of the telephone industry by assigning all of Western Union's telephone rights and patents to the company that was then called National Bell.

A hideous goof? With hindsight, yes—but not in the context of the paradigm within which Western Union was then operating. The agreement did what Western Union most wanted—ensure its control of the telegraph—by seeing to it that local telephone exchanges served a rather limited area and carried only voice messages (that is, personal communications). All business messages that went by wire were to go by Western Union's telegraph (and, of course, all business messages did go by wire in 1879). Furthermore, Bell agreed to pay Western Union a royalty on telephone rentals.

Thus, Bell took on all the risk and expense of a commercially unproved technology. Western Union cemented its mastery of an established and successful technology, eliminated a potential competitor, and took a nice cut off the top. A good deal for Western Union—within its paradigm at the time.

Kantrow's explanation of the limits imposed on corporations by the past is marred by his failure to show effective ways of breaking out of those limits. Kantrow—editor of *McKinsey Quarterly* and a former editor of *Harvard Business Review*—provides only a few examples of specific companies doing what he calls "the correct thing" and offers only the most general advice on how corporations can break out of their paradigmatic constraints.

In *The Creative Corporation*, Karl and Steven Albrecht, the former a management consultant and the latter a freelance writer, focus on how corporations can overcome those constraints. The Albrechts divide corporate innovation into five stages: absorption, inspiration, testing, refinement, and selling.

Each stage requires a role player to shepherd the new idea. The Spotter recognizes the need for new responses to the environment. The Inventor comes up with creative options. The Philosopher provides the intellectual leadership needed to get the right people within the organization to sit up and take notice. The Champion fights for the innovation as being useful, carrying the thinking into action. And the Seller lobbies for the idea within the organization. Only if all these role players succeed will it be possible to introduce something new to the market.

The Albrechts fall short when it comes to showing how to overcome resistance to innovation in the market—where individuals have their own paradigms that need reshaping—but they do a good "power of positive thinking" job in urging innovators to press on despite corporate or historical obstructions that deal with what "everyone knows" can or cannot be done.

Indeed, neither Kantrow nor the Albrechts offer solutions to the difficult problem of gaining societal acceptance of new thinking, which requires new paradigms. Mao Tse-Tung said, "Let a hundred flowers grow; let a hundred schools of thought contend." Fine words—but ones that rang hollow in Mao's China, where it was permissible to cultivate only one of the hundred flowers. That was the paradigm.

We cultivate our paradigms, too, and weed out the ideas we perceive as threatening them. It is from those apparent threats, however, that we will be better able to make our garden grow. High-tech managers who know this will be best poised to reap profits when they sow innovation. ■

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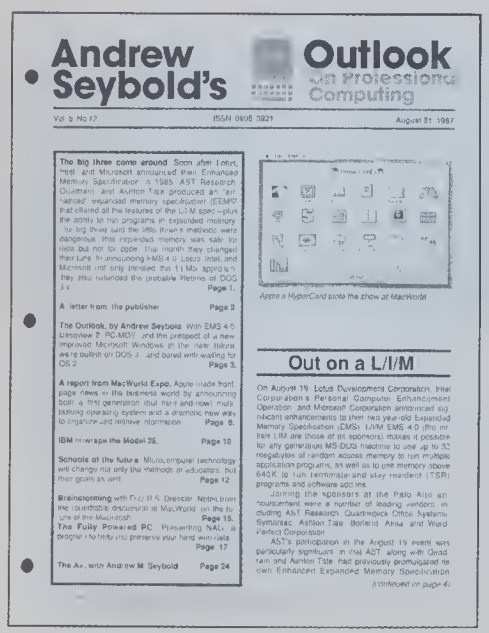

Andrew Seybold's Outlook on Professional Computing

Vol. 9 No. 12 ISSN 0906-3821 August 31, 1987

The big three come around. Soon after Lotus, Intel and Microsoft announced their Enhanced Memory Specification in 1985, AST Research, Quadram and Ashton Tate produced an "enhanced" expanded memory specification (EEMS) that offered all the features of the LIM spec—plus the ability to run programs in expanded memory. The big three said the little three's methods were dangerous; that expanded memory was safe to use but not for code. This month they changed their tune by announcing EMS 4.0. Lotus, Intel, and Microsoft not only blessed the 1 Mb approach, they also extended the probable lifetime of DOS 3.x. Page 1.

A letter from the publisher. Page 2

The Outlook, by Andrew Seybold. With EMS 4.0, Lotus/Intel 2, PC-MOS, and the prospect of a new improved Microsoft Windows in the near future, we're bullish on DOS 3 and bored with waiting for OS/2. Page 3.

A report from MacWorld Expo. Apple made front page news in the business world by announcing both a first generation (but here and now) multi-tasking operating system and a dramatic new way to organize and retrieve information. Page 8.

IBM revamps the Model 25. Page 10

Schools of the future. Microcomputer technology will change not only the methods of education, but their goals as well. Page 12

Brainstorming with Frank R.S. Director: Notes from the (un)official discussion at MacWorld on the future of the Macintosh. Page 15.

The Fully Powered PC. Presenting NAG, a program to help you preserve your hard-won data. Page 17

The Ax, with Andrew M. Seybold Page 24

Apple's HyperCard boils the show at MacWorld.

Out on a L/I/M

On August 19, Lotus Development Corporation, Intel Corporation's Personal Computer Enhancement Operation, and Microsoft Corporation announced significant enhancements to their two year-old Expanded Memory Specification (EMS). LIM EMS 4.0 (the new LIM are those of the sponsors) makes it possible for any generation MS-DOS machine to use up to 32 megabytes of random access memory to run multiple application programs, as well as to use memory above 640K to run terminate-and-stay-resident (TSR) programs and software add-ons.

Joining the sponsors at the Palo Alto announcement were a number of leading vendors, including AST Research, Quadram, Office Systems, Symantec, Ashton Tate, Borland, Aprea, and Word Perfect Corporation.

AST's participation in the August 19 event was particularly significant in that AST, along with Quadram and Ashton Tate, had previously promulgated its own Enhanced Expanded Memory Specification.

(continued on page 4)

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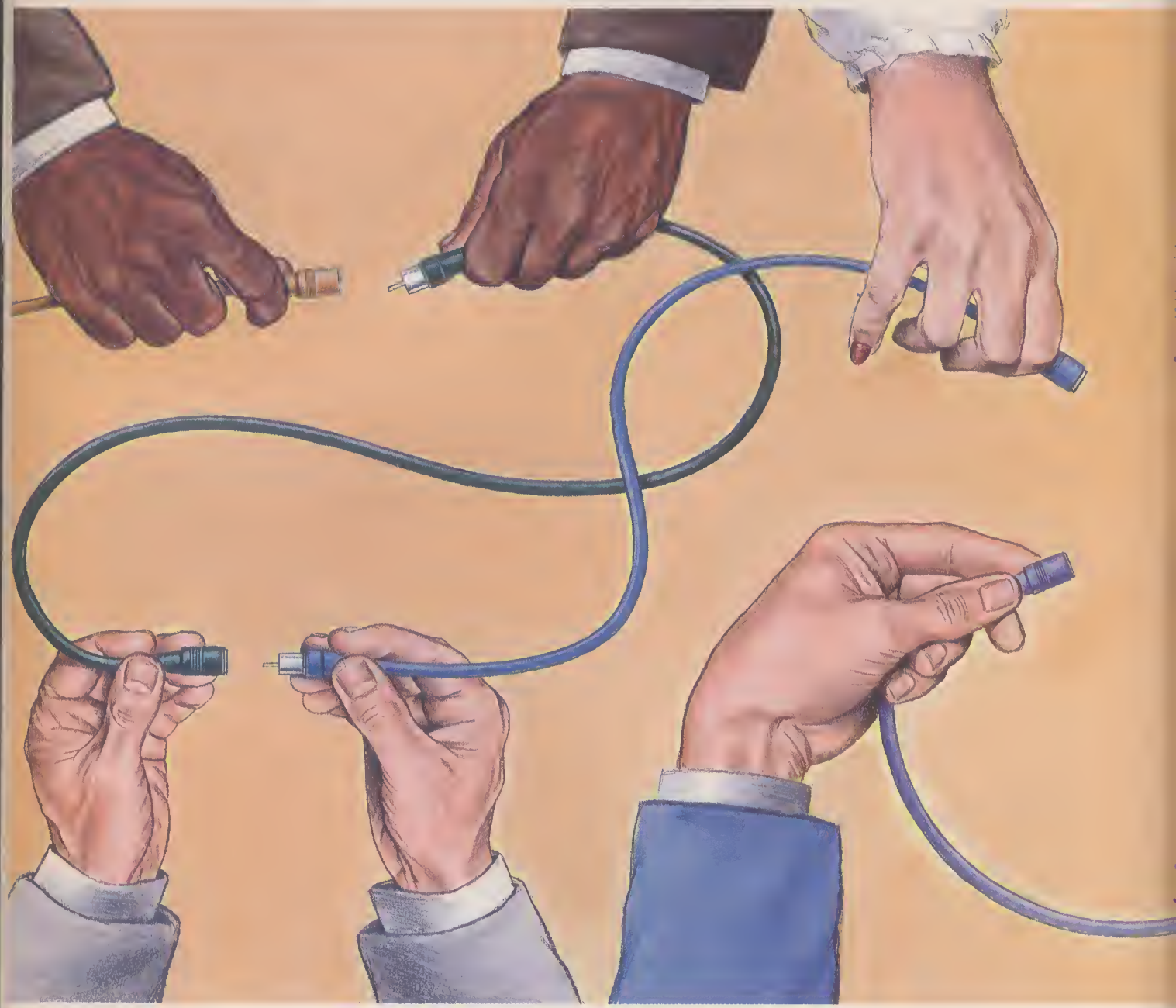

Multi-user database software and diskless personal computers make local-area networks worth having

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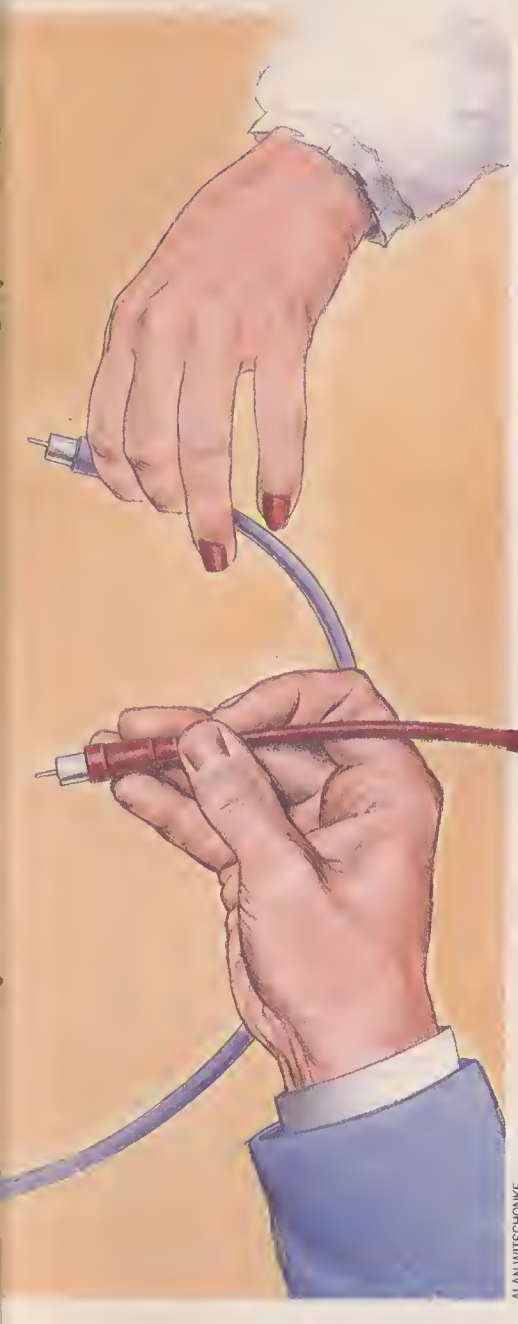
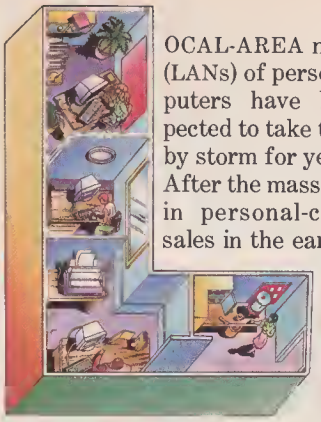


ALAN WITSCHONKE



LOCAL-AREA networks (LANs) of personal computers have been expected to take the world by storm for years now. After the massive surge in personal-computer sales in the early 1980s, industry watchers expected businesses to invest in local-area networks so they could tie all those machines together.

Unfortunately, it hasn't happened that way. So far, only about 10 percent of all personal computers are connected in local-area networks, according to International Technology Group, a market-research company.

On the face of it, this failure to communicate seems mystifying. After all, the local-area network is such a good idea—a group of personal computers linked by circuit boards and cables so they can share software, data, and peripheral equipment such as hard disks and printers. Networks do away with carrying floppy disks from office to office and give a group of workers access to the same information. With a network, for example, a large customer order is immediately known to all concerned, and can immediately affect decisions about how much raw materials to buy or how much tax to expect to pay at the end of the year.

In sum, networks promote the company-wide coordination that executives have long sought.

So why haven't local-area networks sprung up everywhere? Some say dislike for bulky coaxial cables linking computers is one reason, but many networks now take advantage of unused parts of an office's telephone-wiring system. Other network bashers cite a lack of standards, but IBM's Token Ring and the older Ethernet technology have emerged as clear leaders.

What it comes down to is cost. To give users quick access to massive amounts of data, today's networks require powerful, expensive personal computers on each desktop, or an even more expensive minicomputer. Until recently, the software for manipulating large amounts of shared data required so much processing power that it needed a dedicated minicomputer, or a team of fast personal computers.

A new kind of personal-computer program called the database engine, however, lets a company place just one fast personal computer at the hub of its network (see "Software Taps the Power," p. 22). This type of software, which is also called a client-server database, allows networks in which each desktop gets a cheaper personal computer or an intelligent terminal—essentially a personal computer without disk drives.

Diskless personal computers will work on a network because users don't need to store programs and data at their desks; the network holds their data and software. Diskless personal computers are more reliable than standard personal computers, and most important, they help companies control access to sensitive information. As networks become more popular, diskless PCs should become a lucrative market (see "Diskless PCs Protect the Data," p. 25).

As these and other factors come together, networks finally seem ready to realize their potential. An additional spur for growth is the advent of OS/2, the new operating system for IBM and compatible computers, which gives far more support to networks than did DOS, its predecessor.

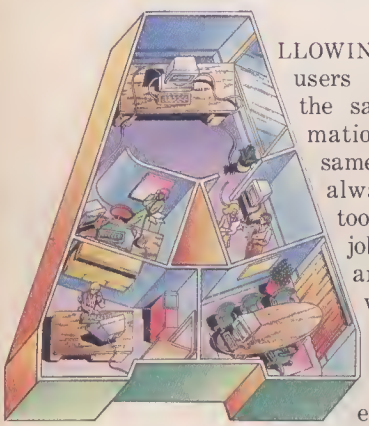
As network growth picks up steam, programs written specifically for use in work groups are finally being introduced. One program called Office Works lets a busy group of networked executives determine the best date and time for a meeting. Another, called For-Comment, allows several workers to comment on and change a document that is stored electronically.

The arrival of useful applications software, diskless personal computers, and the OS/2 operating system could be the keys to the network's success. International Technology Group predicts the market for personal-computer network hardware and software will grow from $3 billion this year to $4.5 billion by 1991. It hasn't happened overnight, but local-area networks may finally be coming of age. ■

Software Taps The Power

Database engines equip personal-computer networks to challenge minicomputers

BY EDWARD WARNER



ALLOWING MANY users to get at the same information at the same time has always been too tough a job for local-area networks consisting of personal computers. Even though today's high-powered personal computers offer roughly the same processing power as IBM's flagship minicomputer, they have lacked the minicomputer's ability to act as a high-speed "filing cabinet" for a network; they just couldn't sort the data and send it out fast enough.

This year, however, a type of software called the database engine is becoming widely available. These programs allow IBM-compatible personal computers to manage the network's shared data and respond to requests for information at minicomputer speeds—for one-quarter to one-tenth the cost.

Unlike earlier database programs for personal-computer networks, database engines put most of the data-handling burden on the network's shared personal computer, or server, not the desktop computer. For example, in a traditional network, an accountant's request for a list of all employees making more than $100,000 annually would cause the server to send the records of all 10,000 company employees to the accountant's personal computer for sorting, bogging down the accountant's machine and tying up the network while the two computers communicated. A database engine would sort out a list of the five employees who qualify and send only those records to the accountant, in a matter of seconds.

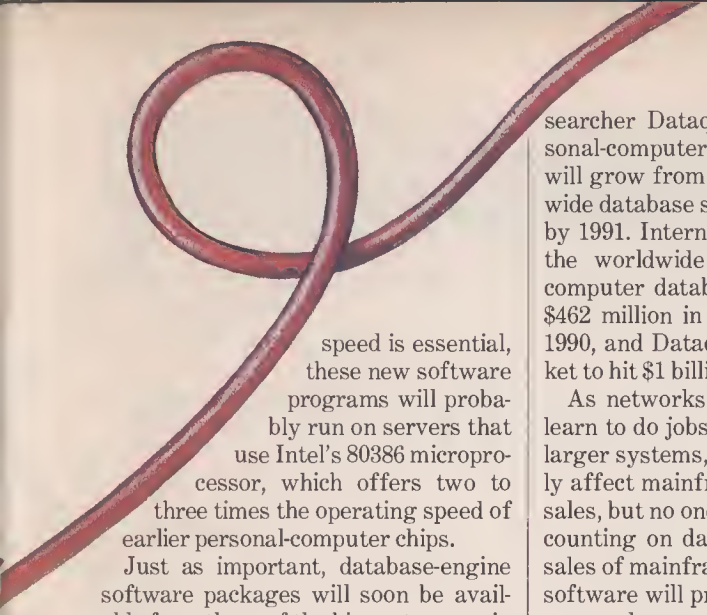
The database-engine method is essentially the way larger computer systems divide their labor. However, mainframes and minicomputers connect to desktop terminals that do not have any computing ability of their own. The host computer must run all the programs for the entire system—a task that can slow even the speediest mainframe.

In a local-area network, each terminal is a personal computer with its own processing power. As a result, the network's personal computers can run their own word-processing or spreadsheet programs while the shared database engine is free to do what it does best: offer ultra-fast responses to data requests. Our accountant, for example, could take the five records received from the server and add their salaries with a spreadsheet program, or merge their names into a mass mailing with a word processor—all without limiting anyone else's access to the company's employment records.

Scenarios like this cause senior consultant Richard Finkelstein of Codd & Date Consulting to observe that "anyone with more than one computer needs a database server."

The savings of replacing a $50,000 minicomputer server with a $5,000 personal computer are obvious. But to be truly useful, database engines must also let more than one user into a file at once. This process, called on-line transaction processing, is the only way a network made up solely of personal computers can provide continuous access to constantly changing data, says Arvind Narain, product marketing manager at Sybase Inc., which sells a database engine. Without up-to-the-minute data, says Narain, it's nearly impossible to manage dynamic situations, be they stock portfolios or factory inventories.

Database engines are not a new concept. Since the early 1980s, several smaller companies have produced them for networks built around minicomputers. But this year's flood of database engines is directed at networks based on personal-computer servers. Because



speed is essential, these new software programs will probably run on servers that use Intel's 80386 microprocessor, which offers two to three times the operating speed of earlier personal-computer chips.

Just as important, database-engine software packages will soon be available from three of the biggest names in the personal-computer industry: IBM, Lotus, and Microsoft. The endorsement of the Big Three will motivate developers to write software for the new database engines, says Mark Finley, a software-industry analyst with the Gartner Group. A database package is nothing, he says, without the programs that equip it to do actual work—payroll and general-ledger software, for example.

The market for personal-computer database engines is so new that its size can only be guessed at. Market researcher Dataquest predicts that personal-computer databases in general will grow from 29 percent of all worldwide database sales today to 36 percent by 1991. International Data Corp. sees the worldwide market for personal-computer databases alone rising from $462 million in 1987 to $690 million in 1990, and Dataquest expects that market to hit $1 billion by 1991.

As networks of personal computers learn to do jobs that formerly required larger systems, their growth will clearly affect mainframe and minicomputer sales, but no one is yet sure how. IBM is counting on database engines to spur sales of mainframes, but others say the software will prompt customers to buy personal computers instead. Minicomputers seem to be caught in the middle.

Microcomputers certainly have the cost advantage. They and their software cost a fraction of what hardware and programs for the largest systems cost. Personal-computer peripherals, such as hard disks needed by network servers, are plentiful and far cheaper than their big-system equivalents.

But IBM product manager Pat Motola predicts a mainframe boom. He thinks personal-computer database engines will spawn a surge in demand for information, and most corporate information is still stored in mainframes.

No one, however, believes personal-computer networks will be good for the minicomputer business. "There'll be a substantial amount of incursion of LANs into minicomputer sales," says analyst Bill Higgs at Infocorp.

Whose database engine will climb to the top of the market? Most observers expect the winning program to be compatible with the OS/2 operating system, and also to support the IBM-developed Structured Query Language (SQL), an emerging standard for requesting information from a database (see "Networks Find the Common Denominator," p. 24). OS/2 lets a personal computer use more memory and communicate better with networks than did DOS, its predecessor. SQL allows computers to access data anywhere on the network, whether that data is stored on a personal computer, a minicomputer, or a mainframe.

IBM, of course, is an SQL leader. It wrote the mainframe database program that popularized SQL and has promised that its personal-computer database engine will work with that program. In other words, IBM is aiming its entry at major businesses where its

DATABASE-ENGINE MAKERS

COMPANY	PRODUCT	PRICE	INTRODUCTION
Ashton-Tate 20101 Hamilton Ave. Torrance, CA 90502 (213) 329-8000	SQL Server (developed with Microsoft and Sybase)	$1,500 to $3,000	Second half of 1988
DSC Communications 2880 North First St. San Jose, CA 95134 (408) 432-6222	NEX/OS	$1,195 to $1,595	Available now
Gupta Technologies 1040 Marsh Rd. Menlo Park, CA 94025 (415) 321-9500	SQLBase	$1,995	Available now
IBM 1133 Westchester Ave. White Plains, NY 10604 (914) 686-1900	Extended Edition (Database Services)	$795	July 1988
Lotus Development 55 Cambridge Parkway Cambridge, MA 02142 (617) 577-8500	Lotus/DBMS	Not available	After October 1988
Microsoft 16011 N.E. 36th Way Redmond, WA 98073 (206) 882-8080	SQL Server (developed with Ashton-Tate and Sybase)	$1,500 to $3,000	Second half of 1988
Migent 865 Tahoe Blvd. Incline Vill., NV 89450 (702) 832-3700	Emerald Bay	$695	Available now
Oracle 20 Davis Dr. Belmont, CA 94002 (415) 598-8000	Oracle for OS/2	$2,495	Available now
Progress Software 5 Oak Park Bedford, MA 01730 (617) 275-4500	Progress (LAN version)	$3,000	Available now
Relational Technology 1080 Marina Vill. Pkwy. Alameda, CA 94501 (415) 769-1400	Ingres (80386 server version)	Not available	Late 1988
Sybase 2910 Seventh St. Berkeley, CA 94710 (415) 548-4500	SQL Server (developed with Ashton-Tate and Microsoft)	$1,500 to $3,000	Second half of 1988
Univation 638 Gibraltor Court Milpitas, CA 95035 (408) 263-1200	LifeNet	$695 to $3,295	Available now
XDB Systems 7309 Baltimore Blvd. College Park, MD (301) 779-6030	XDB network version	About $1,495	Available now

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

NETWORKS FIND THE COMMON DENOMINATOR

How do you spell relief? For a company that wants to store data on several kinds of computers and make that data accessible to everyone, the answer seems to be S-Q-L, the acronym for IBM's Structured Query Language. This software has become an essential ingredient for database programs.

Developed by IBM in the late 1970s, SQL is a set of commands for requesting data from another computer. At its best, SQL's commands do not require the requester to specify which computer contains the desired data. Just as important, SQL works the same way even when several brands and sizes of computers coexist in the same network. This capability makes SQL very popular among the growing number of companies that mix personal computers, minicomputers, and mainframes from several suppliers in one system.

Companies are demanding SQL, says Bill Phelan, product specialist for Progress Software. "You have to have [SQL] because the Requests for Proposals require it to be in the running" for a contract, he says. Progress plans to produce an SQL version of its minicomputer and microcomputer database program soon.

SQL also offers a standard set of restrictions that prevent sloppy handling of data. Bing Yao, president of Software Systems Technology, expects SQL to spur network sales by easing data-processing managers' fears about reduced data security on local-area networks.

But SQL comes in several flavors, each not completely compatible with the others. One version is set by the public body to which IBM entrusted the standard: the American National Standards Institute (ANSI). IBM uses another version in its popular DB2 mainframe database, and is working on a third variation. Product manager Pat Motola says IBM plans to shift completely to the third version of SQL, but will initially include it and the DB2 version in the personal-computer database engine it is developing.

mainframes have long held sway.

The company plans to sell the product, called Database Services, as part of OS/2 Extended Edition, a $795 package that will also have a communications package for company-wide networking and a control screen similar to that of Apple's Macintosh. Other companies sell their database engines alone for as much as $3,000, but Motola boasts that IBM could drop the price of OS/2 Extended Edition to $425.

IBM will initially supply its database engine for stand-alone personal computers only, and the company won't say when the network version will be available. Despite the aggressive pricing, Gartner Group's Finley says the delay could cause software developers to choose database engines that will be available sooner.

The prime candidate to take advantage of this delay is SQL Server, a database engine due later this year from Microsoft, Ashton-Tate, and Sybase.

Sybase, which makes database engines for larger computers, provided the basic technology; Microsoft will sell SQL Server directly to personal-computer manufacturers; Ashton-Tate will market the software through its distribution channels. More importantly, Ashton-Tate will make its market-leading dBase database programs compatible with SQL Server. The company has sold 1.5 million copies of dBase and claims that those dBase users will be able to request data from network servers running SQL Server. That, says analyst Finley, is enough to give SQL Server the critical mass needed to win big.

Lotus Development also chose to develop its database engine in partnership with a smaller company. Lotus' choice, Gupta Technologies, makes a database engine for personal computers running DOS, and Lotus says it will use that product as the basis for its OS/2 database engine, to be called Lotus/DBMS. Like IBM's Extended Edition, the Lotus engine will have a Macintosh-like control screen to make SQL easier to use. Lotus plans to begin deliveries sometime after October 1988.

One reason IBM, Lotus, and Microsoft have teamed up with companies producing minicomputer database engines is that they want their products to be able to exchange information with database engines running on larger computers. Corporations want to share data among several computing systems, creating "distributed databases." Linking personal-computer and minicomputer database engines is a step toward making it easy to get data from any computer within the company.

Oracle Corp., which has been producing SQL database engines for minicomputers since 1979, recently began shipping a personal-computer database engine. Eugene Shklar, director of personal-computer products marketing, says the software will work with other Oracle database engines to access data stored on mainframes, minicomputers, or personal computers.

Another company, Relational Technology Inc., says it will soon introduce a personal-computer database engine that will be able to exchange information with its Ingres minicomputer database program.

Though the future of personal-computer database engines running under OS/2 looks bright, most of those products are still unavailable. People who want such software today must turn to programs that run under DOS. Those programs include Progress Software Corp.'s Progress, Gupta's SQLBase, and Migent Inc.'s Emerald Bay, introduced earlier this year. Software Systems Technology Inc. of College Park, Md., and Miami-based Data Access Corp. may also have products on the market soon.

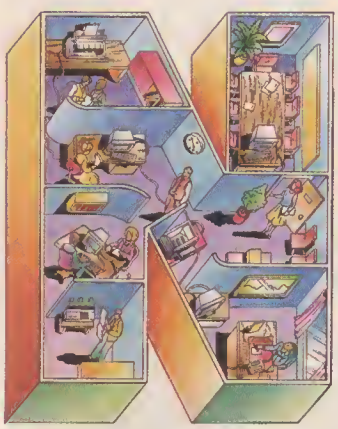
DOS may not be able to match OS/2's technical sophistication, but there are thousands of software developers who have the DOS experience to write application programs, says David Patrick, Migent's marketing vice president.

Personal-computer database engines require a network, but their existence will help justify network installation. Just as the Lotus 1-2-3 spreadsheet spurred sales of IBM-compatible personal computers, database engines could spark widespread acceptance of local-area networks. ■

Diskless PCs Protect the Data

Cheap, secure computers fill network need

BY RANDY ROSS



NOT too long ago, a brother and sister were charged with stealing trade secrets developed by their former employer, the First National Funding Group based in West Covina, Calif. The pair admitted to taking computer disks containing software designed to eliminate hours of paperwork for mortgage bankers, and to using the software to set up their own mortgage company and woo clients away from First National. The thieves, who were charged with embezzlement and grand theft, pled guilty to a lesser charge and were fined $1,000 each. This outcome gave little consolation to First National president Joseph Terror; he estimates that the theft will cost his company as much as $500,000 in lost business.

The incident illustrates how controlling information and data security on personal computers can become a management nightmare. Personal computers give employees unprecedented access to vital corporate information. In a recent survey by the National Center for Computer Crime Data, 16 percent of all computer crimes prosecuted involved theft of information. Many more thefts go unreported because the victims prefer to avoid publicity, says computer-crime specialist Donn Parker of SRI International in Menlo, Calif.

The risks escalate as local-area networks linking personal computers become increasingly common. Network users often have access to vast stores of critical information, not just the information on their desktop. But networks also offer a partial solution, because companies can buy desktop computers that lack the means for users to copy the information they work with—diskless personal computers.

Also called processing terminals or intelligent workstations, these machines have no disk drives for storing data or copying files. Users can still see information on the screen, but they cannot easily walk away with vast amounts of data or the programs themselves. In addition to protecting sensitive data, diskless personal computers can be significantly cheaper than full-fledged models, and thus make networks more economical.

More than a dozen companies now make such computers. The players include full-service computer companies, makers of "dumb" data terminals, and

MATT ZANG

SOURCE: DATAQUEST

companies that concentrate on hardware and software designed to link computers into local-area networks (LANs). And virtually any personal-computer maker could enter the business just by pulling the drives out of its machines. All are chasing a market Dataquest predicts will explode from about $40 million in 1987 to about $1.6 billion by 1992.

Because diskless personal computers work only as part of a network, their market hinges on the success of local-area networks. If database engines can drive the LAN market (see "Software Taps the Power," p. 22), the market for diskless personal computers will have plenty of room to expand.

The relatively small terminal and networking companies reacted to the new market first. But as the market demonstrates its strength, the big computer companies are starting to muscle their way in. "It may be a case of survival of the fittest—and the larger companies have more resources," says Eileen O'Brien of International Data Corp. More resources will help the big companies out-advertise, undersell, and buy out the little guys.

A 1987 Dataquest survey showed Televideo Systems Inc., a terminal maker that has sold diskless personal computers since 1984, holding a 37 percent share of the market, with about 9,250 units sold. LAN-supplier 3Com grabbed 25 percent of the market, even though it introduced its first diskless product just last year. Observers credit 3Com's success to its diskless machine's unique features and positioning as part of a complete system. NCR captured about 8 percent of the market, as did Racore, a peripheral-equipment supplier. Dataquest estimates that 25,000 diskless units were sold in 1987.

However, the survey gives a skewed picture of the total market because it includes only diskless personal computer-compatible devices designed specifically for use on a network. Dataquest did not consider standard personal computers sold with the disk drives removed. For example, last year IBM sold about 4,000 PS/2s with the drives removed to two airlines, United and American. IBM declines to comment on its plans for diskless personal computers.

Until now, most of the larger players have stayed on the sidelines. But within the last year, two large computer companies—NCR and Unisys—have demonstrated new commitment to diskless personal computers. The presence of these well-known players is expected to lend legitimacy to the diskless market. But other large companies have been reluctant to commit to diskless personal computers. "It's a market-demand issue," says Pradeep Jotwani, product marketing manager for Hewlett-Packard's personal-computer group. "If enough people want a [diskless personal computer], we'll produce one."

Enough people already want diskless personal computers to have lured Unisys into the market. Formed in 1986 by the merger of Sperry and Burroughs, Unisys plans to sell about 50,000 of its diskless units within the next year, says Cyril Molnar, product marketing manager. Major customers will include large corporate clients, universities, and government installations.

NCR recognized the need for diskless personal computers when it introduced its first model back in 1986. The company expects demand to jump as networking increases, according to Louis Barten, assistant vice president for NCR's personal-computer division. "Previously, people exchanged diskettes, but now they realize you can store files on a central processor or send them [to a co-worker's computer]; this limits the need for floppy disks," he says. The company beefed up its line by introducing a new diskless computer last summer. "We plan to be a very strong force in this market," says Barten.

While NCR and Unisys plunge in, IBM and DEC have refused to do more than get their feet wet. Analysts explain the reluctance by pointing out that diskless personal computers could cut into corporate sales of conventional personal computers and high-end terminals that lack processing capacity.

Price is also an issue. Diskless units can cost as much as 30 percent less than a comparable personal computer. Gartner Group analyst Patricia Woo says 3Com's diskless 3Station, which sells for $1,895, matches the processing power of a high-end personal computer that sells for $2,500. Bare-bones diskless computers can be found for as little as $700, minus monitor and keyboard, and higher-end models with graphics cards and network-interface hardware run about $2,200. A fully loaded IBM PS/2 can cost almost $4,000.

Lower prices may be good for customers, but they make diskless computers less profitable for both manufactur-

ers and suppliers. "It's like a car salesman who'd prefer to sell you the loaded model over the economy model," says one New York analyst, who asked to remain anonymous. Still, he predicts more full-line computer companies will eventually enter the diskless market.

The smaller companies that concentrate on making computer terminals—including Televideo, Kimtron Corp., Wyse Technology Inc., and Esprit Systems Inc.—are expected to continue to be important players. But because the terminal companies sell only desktop devices, not complete systems, they will have a hard time competing for large corporate accounts.

Terminal makers claim their niche marketing strategies will keep them competitive. Televideo, the current market leader, sells most of its diskless products to small retail stores, local banks, doctors' offices, and clinics, says Ron Nakashima, director of systems product marketing. "It doesn't make sense for us to knock heads with [large computer companies]," he explains. Nakashima claims that Televideo can come up with new products faster and fill gaps in the major companies' product lines. "If they offer a machine based on [Intel's] 80286 processor, we'd come out with one based on [Motorola's] 8088 chip," he says.

In January, Esprit Systems introduced a diskless personal computer that looks like a dumb terminal; its LAN Term computer rolls the monitor and central-processing unit into one package. Ernie Wassman, Esprit's director of product marketing for LAN peripherals, says terminal makers may have a unique advantage over more diversified companies because they specialize in meeting the needs of their clients' office environment, including packaging, styling, and user interfaces.

Unlike most other terminal companies, Wyse Technology of San Jose, Calif., may have what it takes to go head to head with larger computer companies. As one of the largest terminal vendors, Wyse has experience marketing personal-computer products, says International Data's O'Brien. Wyse may offer a diskless product by the end of the year, says Rollie Schmidt, product-marketing manager for Wyse's terminals division. If Wyse does enter the diskless market, the $400-million company's comparatively large size will help it compete on price. "We like to build high-volume products around industry standards," Schmidt says.

Even as the market for diskless personal computers grows, it remains a subset of the LAN market, and several companies are trying to use their networking experience to enter the diskless business. Some diskless models include hardware to allow instant hookup to popular LAN systems.

But LAN companies face stiff competition selling diskless PCs. One major LAN player, Novell Inc., is already deemphasizing hardware in favor of higher-margin software products, says Therese Murphy, an analyst at Kidder Peabody. Novell, which introduced its diskless PCTerminal based on a Hyundai personal-computer clone last spring, says it plans to reduce the role of hardware in its product mix from 50 percent to 30 percent by year's end.

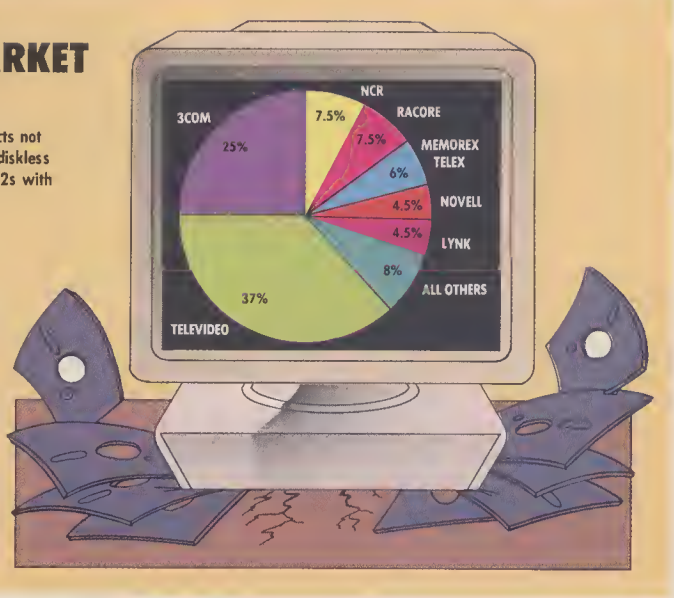
Another LAN company has abandoned the personal-computer market entirely—Corvus Systems Inc. of San Jose, Calif. Personal computers, including diskless models, are becoming commodity products, and the company can't compete on price, says William Halford, vice president of marketing. Since Corvus discontinued its personal-computer products, it has had its first profitable quarter in almost three years, says Halford. Corvus plans to concentrate on higher-margin networking products, which it hopes to differentiate by technology, not price.

At least one LAN specialist has a viable diskless product. 3Com sells its 3Station as part of a complete office system, including a network and software. "3Com is closer than the other [LAN companies] to providing a complete solution," says Kidder Peabody's Murphy. 3Com is well positioned in the networking market because its systems connect to a variety of larger computer systems; products from IBM, DEC, and Hewlett-Packard generally work only with their own systems.

Despite the market wars, however, the impetus for diskless personal computers is coming from users, not suppliers. The machines are attracting attention because they offer a solution to the problems created by the rise of networks. Combining the brains of a personal computer with the information-management features of a dumb terminal, smaller diskless devices can run popular software such as word-processing programs and spreadsheets. No disk drive means a smaller computer with fewer moving parts to wear out.

1987 MARKET SHARE

Does not include products not generally available as diskless versions (e.g., IBM PS/2s with drives removed).



MATT ZANG

SOURCE: DATAQUEST

MAKERS OF DISKLESS PCs

COMPANY	1987 REVENUE	PRODUCT, PRICE	FEATURES	EXPECTED SALES
COMPUTER COMPANIES				
AST Research 2121 Altan Ave. Irvine, CA 92714 (714) 863-1333	$206 millian	Diskless version of AST Premium Workstotion, $2,295	80286 processor; keyboard; EGA graphics	Not available
Convergent Technologies 2200 Narth First St. San Jose, CA 95150 (408) 434-2848	$400 million	Network PC, $1,770	80286 processor; no keyboard, manitar, or LAN interface; EGA graphics	$4 millian
Datamedia 11 Trofolgar Squore Noshua, NH 03063 (603) 886-1570	Not available (Privately held)	Colorscan/2, $2,000	NEC V30 pracessar; monitor and keyboard; na LAN interfoce; EGA graphics	Not available
NCR 1700 S. Patterson Blvd. Dayton, OH 45479 (513) 445-5000	$5.6 billion	3392 Workstation, $1,974	80286 processor; no manitar, keyboard, or LAN interface; CGA grophics	Not ovoiloble
Tandem Computers 19191 Vallco Porkway Cupertino, CA 95014 (408) 725-6000	$1 billion	P5X Workstation, $1,195	80286 processor; keybaard; no LAN interface, graphics, or monitor	Not available
Televideo Systems 1170 Morse Ave. Sunnyvole, CA 94088 (408) 745-7760	$100 million	NW5/286, $1,695	80286 processor; LAN interface, manitor, and keybaard; Hercules or CGA graphics	$20 million
Unisys Box 418 Detroit, MI 48232 (313) 972-7000	$10 billian	PW^2 Series 300, $1,305	80286 processor; na monitor, keyboord, or LAN interface; EGA graphics	Not ovailable
TERMINAL COMPANIES				
Esprit Systems 100 Morcus Dr. Melville, NY 11747 (516) 293-5600	$24 millian	LAN Term, $1,095	NEC V40 processor; monitar, keyboard, ond LAN interface; Hercules graphics	$6 million
Kimtron 1709 Junction Court San Jose, CA 95112 (408) 436-6550	Not availoble (Privotely held)	Satellite workstotions, $899 to $999	NEC V40 pracessor; keyboord and manitor; LAN interfoce on some models; EGA graphics	Not available
Lynk 101 Queens Dr. King of Prussia, PA 19406 (215) 265-3550	$12 millian	Computing/I, $2,175	8088 processor; manitar, keyboard, ond LAN interface; CGA grophics	$8.7 million
LAN COMPANIES				
Novell 122 East 1700 South Provo, UT 84601 (801) 379-5900	$183 million	PCTerminal, $795	8088 pracessor; monitor, keyboard, and LAN interface; Hercules grophics	Not ovoiloble
Racore Computer Products 170 Knowles Dr. Los Gatas, CA 95030 (408) 374-8290	Less than $10 million	LANstotion, $599 to $1,279	8088 or 80286 processor; no LAN interface, graphics, manitor, or keyboard	$5 million
3Com 3165 Kifer Rd. Santo Clora, CA 95052 (408) 562-6400	$156 millian	3Station, $1,895	80286 processor; LAN interface ond keybaard; no monitor; EGA, CGA, and Hercules grophics	Not ovailable
OTHER				
Memarex Telex 6422 East 41st St. Tulso, OK 74135 (918) 627-1111	$2 billian	Telex 1210, $2,020	80286 processar; monitor; no LAN interface or keyboard; CGA, EGA, and Hercules graphics	Not available

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

To make up for missing functions, however, a diskless personal computer depends on the network to do many things a standard personal computer does for itself. Diskless personal computers need a central database, whether on a mainframe, minicomputer, or high-powered personal computer, to store and download data and software. But having all the data in one place allows the entire network to update data and software at once. That centralization could save a company with 6,000 desktop computers $8,000 in labor costs every time a program needs to be upgraded, estimates Igor Crkvencic, a computer manager at the New York accounting firm of Rapp & Collins.

Of course, diskless personal computers aren't the answer to every problem. Many information managers worry that diskless machines are useless if the host computer or network server fails, says Thomas Davenport, research director for Index Group, a consulting firm. He also notes that high-ranking executives generally want to control their databases and software themselves; vice presidents of marketing will not be thrilled about giving up that control to the microcomputer manager. Diskless personal computers will instead serve large groups of lower-level employees who don't need the flexibility of local storage, Davenport says.

The travel industry has been a leader in acquiring diskless computers. Soon after IBM introduced its PS/2 personal computer last year, American Airlines and United Airlines each requested about 2,000 of the devices without local storage for use in travel-agent reservation systems. The airlines say they went diskless mainly to save money.

As more and more offices set up local-area networks, the diskless personal computer market will inevitably heat up. But in the meantime, the market is still so unformed that every new company, every new deal, can rearrange the competitive balance. And market share won't necessarily mean profits, as diskless personal computers threaten to cannibalize sales of more profitable personal computers and terminals.

If local-area networks finally achieve their long-anticipated breakthrough, diskless personal computers are sure to follow. But diskless units will not realign the computer industry; no Apple Computers will ride the diskless boom into the big money. Users, not suppliers, will be the major winners. ■

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Defense Contractors Target Electronics

A rash of acquisitions and sellouts consolidates power in the hands of a few giants

BY JEFF BRODY

THE BUSINESS OF defense-electronics is going through a prolonged spasm of consolidation that is changing the nature of the industry. Despite deep cuts in a number of military programs as President Reagan nears the exit door, spending on electronic systems remains largely intact. Thus companies that want more Pentagon dollars are snapping up small, entrepreneurial outfits that specialize in such hot electronic areas as antisubmarine warfare and surveillance.

Meanwhile, several diversified industrial companies are selling off their defense-electronics units. Corporations such as Singer, Eaton, and Gould have decided to concentrate on their commercial activities, largely because a new, tougher military-contracting environment makes defense work too financially risky, they say.

It seems that every defense-electronics player is either buying someone else or being bought—a process that spans the Atlantic. The weak dollar makes U.S. companies bargains for overseas players looking for a shortcut into the U.S. market. In recent months, several European companies have bought U.S. defense-electronics firms, raising questions about national security (see "Foreign Companies Buy Pieces of America's Defense," p. 34).

As a result, the number of independent defense companies is rapidly dwindling. There have been more than a dozen acquisitions in the past two years. If present trends continue, by the mid-1990s the $50-odd billion defense-electronics business will be concentrated at a few large military contractors.

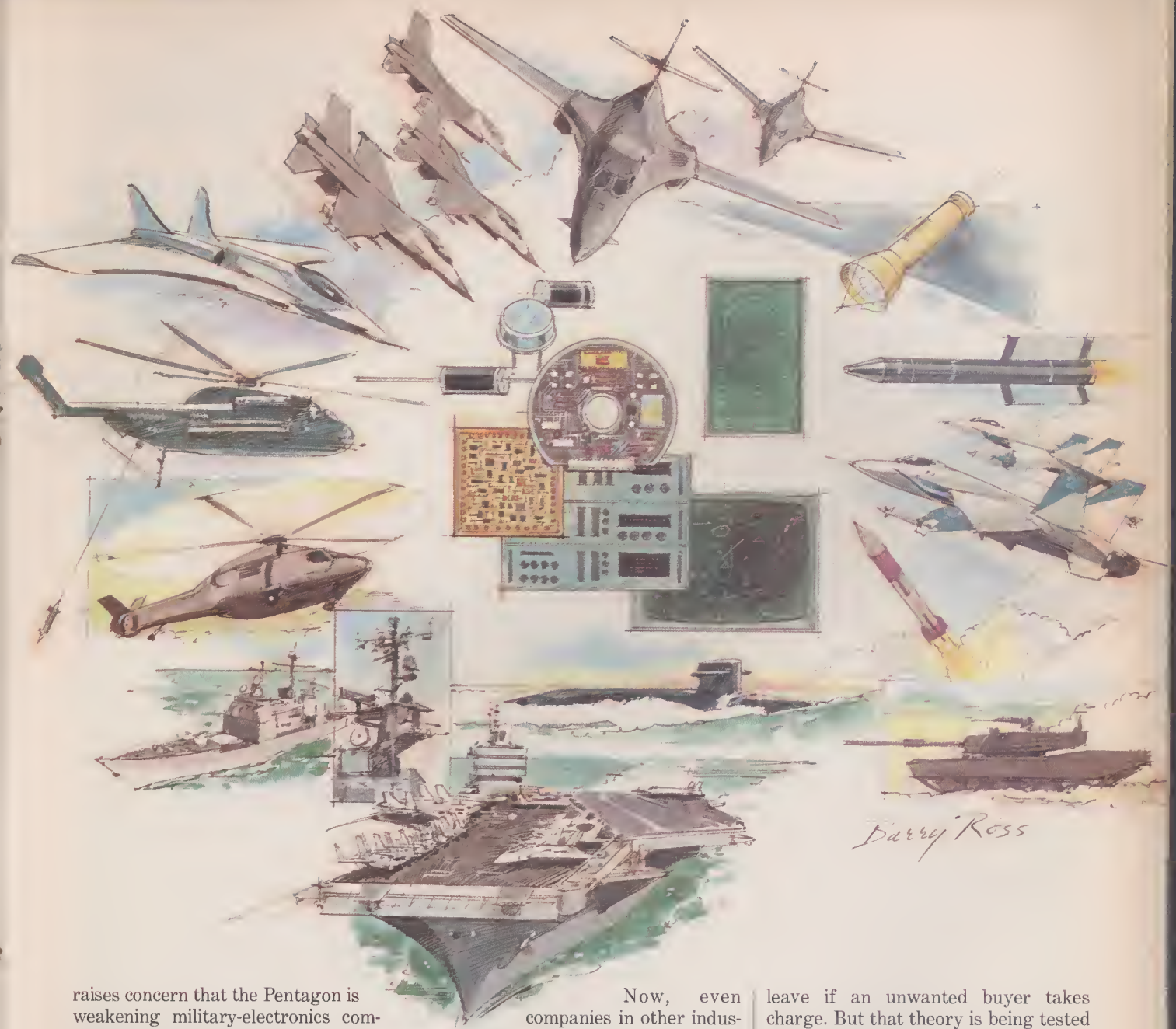
Not all defense-electronics specialists are attractive takeover targets; activity centers on small but growing niches, especially intelligence-gathering and antisubmarine warfare. For instance, Diagnostic Retrieval/Systems of Oakland, N.J., which makes antisubmarine equipment, is frequently mentioned as a possible target. But takeovers remain unlikely in more mature segments such as microwave components.

The consolidation trend has accelerated since the stock-market crash. Low stock prices make it cheaper for a military supplier to buy a company rather than develop electronic systems on its own. Not that the crash alone drove down stock prices. Foreseeing the era of tighter military budgets, investors cooled to defense companies well before October 19; stock issues that had been selling for more than $30 a share had slipped into the $20s. "The budget outlook has been deteriorating since 1985," says Oppenheimer analyst Michael Lauer. Now, however, takeover rumors are nudging the stock prices of many small companies upward from their post-crash lows.

The Pentagon's $291-billion fiscal-1989 budget proposal is up less than 3 percent from 1988. Despite such stagnation, analyst Lior Bregman of Hambrecht & Quist calls electronics "one of the few growth areas" in the defense budget. That's because Congress is saving the big bucks by cancelling or delaying major projects—such as developing new aircraft and missiles—and improving its existing equipment by packing it full of advanced electronics. Thus, defense-electronics suppliers can stay busy making the latest generation of things like radar, computers, and jammers (known in the trade as electronic countermeasures).

Indeed, in a few cases the military is assigning *prime* contracts to electronics houses. E-Systems of Dallas, for example, holds the prime contract for the F-4 Wild Weasel aircraft, a Vietnam-era fighter that is being gutted and then stuffed with new electronics. Traditionally, prime contracts have gone almost exclusively to major airframe companies such as Boeing, McDonnell Douglas, and Lockheed. These giants then hired the smaller specialists to do the electronics work.

Still, upgrade projects are a meager substitute for the billions of dollars spent on developing new systems. That



raises concern that the Pentagon is weakening military-electronics companies. "They're just being starved more slowly," say UBS Securities' Wolfgang Demisch, an aerospace analyst.

But even slow growth is better than no growth, making electronics companies juicy targets for aerospace and defense outfits that count on the military for a hefty portion of their sales. General Motors kicked off the present round of acquisitions with its 1985 purchase of Hughes Aircraft, a leading maker of military radar and laser systems. Subsequently, Lockheed bought electronic-warfare specialist Sanders Associates. In the past year, Boeing bought Argo-Systems, another electronic-warfare house, and Chrysler purchased Electro-Space Systems.

Now, even companies in other industries are sniffing the wind, extending the acquisition frenzy beyond the aerospace fraternity. For instance, Parker-Hannifin, which makes hydraulic and pneumatic systems for cars and industrial equipment, acquired Gull, a supplier of electronic fuel gauges for aircraft. Another example: Westinghouse bought Gould's torpedo organization, which is rife with electronics expertise because most of a torpedo's value lies in its guidance system.

The takeover game is getting decidedly unfriendly. Traditional wisdom holds that hostile takeovers don't work in the defense-electronics business; such a company's treasure is its engineering talent, which presumably will leave if an unwanted buyer takes charge. But that theory is being tested as corporate raiders arrive on the scene, scavenging for companies worth more for their inventories than as continuing operations.

In 1986, for example, electronic-warfare specialist Loral moved in on Sanders, a supplier of similar products. When Sanders resisted the takeover bid, Lockheed stepped forward as a white knight and bought Sanders to spare it the humiliation of being swallowed by its competitor. Lockheed, which sees its own future largely defined by its electronics capabilities, has preserved Sanders' operations as a separate division; Loral probably would have dismembered the company.

Consider, too, the pitiful case of Sing-

DEFENSE BUYOUTS GATHER MOMENTUM

DEAL COMPLETED	BUYER	MAIN PRODUCTS	COMPANY ACQUIRED	MAIN PRODUCTS
August 19B6	Lockheed 4500 Park Granada Blvd. Calobasas, CA 91399 (B1B) 712-2000	Aircraft, missiles, sotellites, and defense electronics	Sanders Nashua, N.H.	Rodor ond electronic cauntermeasure systems, graphics terminols, and sonar training equipment
December 1986	Emerson Electric B100 W. Florissont Ave. Saint Lauis, MO 63136 (314) 553-2000	Variaus electronic ond electrical equipment for defense, consumer, commerciol, industrial, and government morkets	Hazeltine Greenlawn, N.Y.	Electronics for surveillance, communicotions, and microwove systems
March 19B7	Loral 600 Third Ave. New York, NY 10016 (212) 697-1105	Defense-electronics systems	Goodyear Aeraspace Akran, Ohio	Defense-electranics systems
August 19B7	Baeing Box 3707 Seattle, WA 9B124 (206) 655-2121	Commercial and military aircraft, missiles, and infarmation systems	ArgoSystems Sunnyvale, Calif.	Reconnaissonce systems
August 1987	Chrysler 12000 Chrysler Dr. Highlond Park, MI 4B203 (313) B76-5741	Automobiles and commercial jets	Electrospoce Systems Richardson, Tex.	Electronic-worfore equipment and systems for cammand, control, and communications
September 19B7	GEC PLC Airport Warks Rochester, Kent, England (011) 441-634-4440	Various electronic ond electricol equipment for defense, commercial, and consumer morkets	Lear Siegler Astronics Division Santa Monica, Calif.	Aircroft electronics, ground radar systems, and remotely piloted vehicles
December 1987	Plessey PLC 21-24 Millbank London SW1P 4QP (011) 441-B34-3B55	Variaus electronic ond oerospace products	Sippicon Morion, Moss.	Equipment for ontisubmarine worfare and submarine communicatians
December 19B7	Westmork Systems 301 Congress Ave. Austin, TX 7B701 (512) 322-0222	Holding compony formed to acquire defense-electronics companies	Trocor Austin, Tex.	Defense electronics, onalytical equipment, and electronic components
February 19BB	Parker Honnifin 17325 Euclid Ave. Cleveland, OH 44112 (216) 531-3000	Various aerospoce, industrial, automotive, spoce, ond marine products	Gull Smithtown, N.Y.	Electronic fuel gauges
April 19BB	Bilzerian Partners Limited Partnership 1 B Stomford Forum Stamford, CT 06904 (203) 356-4200	Investment graup	Singer Stamford, Conn.	Various oerospoce and defense-electronics equipment
Moy 19BB	Hughes Aircraft 7200 Hughes Terroce Los Angeles, CA 90045 (213) 56B-6327	Defense electranics and commercial communications systems	Rediffusion Simulation Crowley, England, and Arlington, Tex.	Flight simulators
May 19BB	Tracar 6500 Trocor Lane Austin, TX 7B725 (512) 926-2B00	Defense electronics, analytical equipment, and electronic companents	Elsin Sunnyvale, Calif.	Receivers and digital signol processars far communications ond rodar
Pending agreement to buy os much as 50 percent interest	British Aerospace 11 Strand London, England (011) 441-930-1020	Aeraspace products	Reflectane Tampa, Fla.	Flight simulotors and information systems
Pending	United Scientific 10 Fitzroy Square London, England W1P 6AB (011) 441-387-7224	Night-vision systems	Varo Garland, Tex.	Night-visian systems

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

er. Known to consumers for its sewing machines, Singer dramatically shifted its focus toward defense over the past decade; in 1987, $1.5 billion in revenues from a diverse batch of defense-electronics divisions comprised more than 80 percent of the company's total business. Last fall, with its stock price battered by the crash, Singer fell victim to a corporate raider—Paul A. Bilzerian—intent on breaking up the company.

When Bilzerian's investment partnership, based in Tampa, Fla., offered $50 a share for Singer stock, company management searched in vain for a savior within the defense community. No one came forward with a higher bid, however, and in April the acquisition was completed.

The successful raid on Singer seems to have precipitated other hostilities. In one unusual maneuver, Britain's United Scientific is trying to force a merger with Varo of Garland, Tex.; rarely has a foreign company attempted an unfriendly takeover of a U.S. defense contractor. Both companies make image-amplifying devices that enable tank and aircraft operators to see at night. United Scientific was drawn to the deal by Varo's post-crash stock price of $7 a share. That's essentially the value of Varo's real estate, says analyst Lauer. By late April, the British company had grabbed almost 10 percent of Varo's stock, and was expected to buy more.

Some analysts say the Singer and Varo deals rang the closing bell on the first round of defense-electronics takeovers. "The acquisitions are over," says Judith Comeau of Goldman Sachs. "There have been so many mergers that the industry's appetite is satiated."

In recent months, the industry's focus has shifted from acquisitions to divestiture, particularly by companies that do not specialize in defense. Bilzerian has put most of Singer's defense-electronics operations on the block in an effort to cash in quick on the acquisition. Gould, too, is backing out of the business, as witnessed by the sale of its torpedo division. And United Technologies, while holding on to most of its defense units, is seriously considering selling Norden Systems, an unprofitable radar systems operation. "The troubled companies are starting to sell out," says Thomas Lloyd-Butler of Montgomery Securities.

In perhaps the most dramatic departure, Eaton is trying to sell off its AIL electronic-warfare division, which makes radar jammers. In 1987, Eaton enjoyed defense-electronics revenues exceeding $900 million, accounting for more than a quarter of the company's total revenue. But with AIL's bread-and-butter project—the B-1B bomber—coming to an end, Eaton decided to exit the military arena. In a letter to stockholders, chairman James R. Stover explained that the company could no longer justify the enormous cost and financial risk required to compete effectively for defense contracts. "We must get bigger or we must get out," said Stover. The latter choice prevailed, and Eaton will now concentrate on its core business: manufacturing components for cars and trucks.

■

The consolidation in defense electronics reflects corporate America's notorious short-sightedness.

■

Eaton's move underscores the significance of the new set of Defense Department policies that shift more risk to the contractor. These changes, stemming from a variety of legislative and executive processes, hit especially hard at research-intensive businesses. The new policies require contractors to pay research and development costs previously assumed by the government.

In addition, contractors must accept slower payment. Until recently, companies could bill the government throughout the course of a program, receiving so-called progress payments of 90 to 95 percent of the total program cost. Now, however, the government pays only about 75 percent of the total cost before program completion, severely cramping cash flow.

Responding to reports of overpricing, Congress restricted single-source contracts, in which the Pentagon essentially selects its supplier. Before this rule change, less than half of all contracts involved competition; now more than 90 percent of all contracts are awarded after competitive bidding. Also, the government has largely ceased "cost-plus" programs, in which the contractor receives its costs plus a profit margin negotiated in advance. Virtually all contracts now have a fixed price, so the contractor must swallow any cost overruns or unforeseen expenses. In sum, contractors must finance more of their own defense work. The business "just isn't fun anymore," says analyst Robert Hanisee, president of Seidler Amdec Securities.

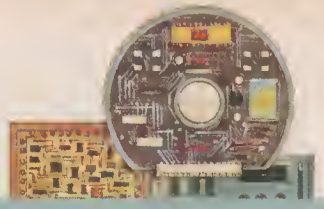
For the short term, at least, these measures give the government more value for its defense dollar. But by forcing competition, the government is fueling the industry's fundamentally anti-competitive consolidation trend, says Bregman of Hambrecht & Quist. Moreover, shifting risk to the contractor "disproportionately hurts smaller companies working in forefront technologies," says Demisch.

Therefore the hunting expeditions of larger companies aren't necessarily unwelcomed by all small defense-electronics firms. Acquisition offers investors a well-timed opportunity to cash in. Not all small defense-electronics companies face this opportunity, however. Players in slower-growth areas, such as microwave components, tell a different story.

"Our customers have never had it so good," says Gary Harmon, chief financial officer at Avantek, a component supplier based in Santa Clara, Calif. "They play one component maker off against another to get the best deal—they don't need to buy a whole company." Avantek's 35 percent annual revenue growth of the late 1970s and early 1980s has come to a screeching halt. Sales in 1987 were $213 million, a barely perceptible increase from the previous year's $208 million. Avantek hopes sales will pick up when the military starts buying multifunction assemblies, which mingle several microwave circuits in a compact package.

For the large defense companies doing the buying, the benefits outweigh the financial risk. These suppliers of big planes and weapons desperately need electronics capability, because conventional U.S. military strategy relies on technological advances to maintain an edge over the far more numerous Eastern-bloc forces. Acquisition gets the buyer past the entry barriers of the defense business; credibility takes years to establish, especially in top-secret work such as electronic-warfare technologies. "It's hard to get tickets to

FOREIGN COMPANIES BUY PIECES OF AMERICA'S DEFENSE



Encouraged by a weak dollar and low post-crash stock prices, European companies are rapidly establishing a presence on the U.S. military scene. "The Europeans have entered the feeding frenzy," says Robert Fraser, chief aerospace/defense consultant at Arthur D. Little.

Most of the action over the past year has come from Britain. General Electric Co. (known as GEC and unrelated to the U.S. GE) bought Lear Siegler's Astronics division, which makes electronics for aircraft; Plessey, a diversified electronics producer, bought Sippican, which makes oceanographic equipment useful in antisubmarine warfare. United Scientific surprised analysts with its unsolicited bid to buy Varo; both companies make night-vision equipment. Hostile takeovers are unusual when there is so much proprietary technology involved, says Robert Hanisee, president of Seidler Ametek Securities. Marconi and British Aircraft are reportedly on the prowl as well.

This transatlantic assault makes sense for the Europeans. With the dollar worth less, U.S. companies can be bought cheaply. Also, Europeans tend to take a longer view of business success and resist the profit squeeze that is driving U.S. outfits such as Eaton and Singer out of defense, along with many investors.

Several major European companies want to get into the aerospace industry for competitive reasons, says Fraser. The military's extensive research sponsorship helps its contractors stay on technology's leading edge—giving a company expertise that could spill into its civilian business. However, many U.S. companies are finding it more cost-effective to develop technology free from the constraints of military contracts.

Foreign acquisitions of U.S. defense contractors have raised security concerns. Some fear the trend may invite repeats of the Toshiba affair, in which the Japanese company drew fire for selling machines able to produce ultra-quiet submarine propellers to the Soviet Union. But in a larger context, Europe's entry can be viewed simply as further evidence of the vanishing national boundaries in the defense business. Other evidence of globalization, says Fraser, includes the landing gear for the DC-9-80, which is made in China. Nearly half of Europe's Airbus aircraft is American-made. The French electronics giant Thomson-CSF has a $4-billion contract to supply the U.S. Army with its next generation of tactical mobile radios. (Thomson subcontracted much of the electronics production to GTE.) The standard U.S. Army sidearm, says Fraser, is an Italian-made pistol.

Recent congressional action assures that such involvement will increase over the coming years. The so-called Nunn amendment of 1986 requires that several hundred million dollars be spent jointly developing weapons systems with other NATO countries. Therefore, before the Pentagon embarks on major new weapons-development programs, officials must first check to see if European allies are making something similar. This policy, which aims to avoid costly duplication of effort, will also bolster the revenues of Europe's companies.

these programs," says Robert Fraser, who heads the aerospace/defense practice at consulting firm Arthur D. Little.

Boeing's major purpose in acquiring ArgoSystems, for example, was to get access to the smaller company's customers in the intelligence agencies. It would have taken Boeing a long time to crack these markets on its own, observes analyst Phillip Friedman of Drexel Burnham Lambert.

To some extent, the consolidation in defense electronics reflects corporate America's notorious short-sightedness. Companies are being acquired because their stock is cheap. This devaluation stems from investor nervousness over short-term profits—even though the long-range outlook for the industry is bullish. "The Wall Street community doesn't know what it's doing," says analyst Lauer.

At least one organization recognizes this—the holding company Westmark Systems Inc., which was formed in 1986 to acquire undervalued defense companies for their longer-term promise. Switching such companies from public to private status frees them from the tyranny of the quarterly report, says Admiral Bobby Inman, Westmark's chairman and president. Without the burden of satisfying stockholders, private outfits can invest in more exploratory projects whose payoff may be years away.

Westmark's first holding is Tracor of Austin, Tex. Purchased last fall, the company provides technical services to the U.S. Navy and manufactures electronic-countermeasure equipment. In 1986, Tracor's last full year as a public company, sales reached $632 million. Currrently Tracor is engaged in more than 400 contracts for some 85 agencies. In January, Tracor even entered the takeover game, buying Ultron Labs, a maker of cryptographic systems for data security.

Inman and other defense-industry bulls hope to capitalize on favorable long-term trends. The business of upgrading old weapons and aircraft should thrive, for example, with the advent of a practice called pre-planned product improvement. The idea is to design equipment to be upgraded later, when more advanced technology becomes available—much as personal computers have empty slots for expansion boards.

And despite today's paucity of programs, the Pentagon has hardly given up on building new aircraft. Upcoming projects include the Advanced Tactical Fighter, the LHX light helicopter, and the V-22 vertical-takeoff plane. Such major efforts promise billions of dollars in electronics business.

Most analysts predict that the takeovers will continue for the next year, albeit more slowly. In the fickle financial community, however, the bloom is off the defense-electronics rose. The handful of entrepreneurs who have held on to their companies may soon find that their big chance to cash in has passed them by. ■

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Frank Popoff

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Joined Dow: 1959
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Employees: 53,100
1988 R&D budget: $730 million

DOW CHEMICAL, based in Midland, Mich., is the nation's second largest chemical company, but its market battles are not restricted to other chemical giants. Dow sells plastics that compete with steel for a place in such industries as automobiles. The company's sales of pharmaceuticals and agricultural chemicals put it nose to nose with biotechnology companies, and its expertise in plastic films breeds consumer products such as Saran Wrap and Ziplock bags. Dow also sells building products that may sit beside the plywood in a lumber yard.

All of Dow's diverse products begin as chemicals. Technological innovation, the second ingredient, turns the basic chemicals into new products that hopefully lead to growing business.

This strategy is working. Dow turned in record 1987 revenues and earnings, and expects the same this year. To find out how research and business strategies are keeping Dow on the growth curve, HIGH TECHNOLOGY BUSINESS associate managing editor Jeffrey Zygmont spoke with president and chief executive Frank Popoff, who has been with the company 29 of its 91 years.

■ *HT Business: Dow is currently experiencing record earnings. What are you doing right?*

POPOFF: Early in the 1980s, Dow and the industry recognized that growth rates had diminished. During the 1960s

KEVIN HORAN

and 1970s, double-digit growth was not uncommon. But in the early 1980s, we recognized that growth was going to be only 2 or 3 percent per year. It was clear to us that we had to restructure.

So people set about doing two things: Rationalizing excess capacity, because we were overbuilt, and investing in the value-added end of the business, which requires human resources, technology, discovery, and innovation. Our strength is now in technology and value-added human resources rather than raw-material resources. That goes well for companies that spend a lot of money on research and development—that are willing to create ideas, concepts, and inventions through capital investment.

This change really liberated the industry, leading it to a restructured 1985, an improved 1986, a superior 1987, and I think a still-better 1988 if the economy holds up, and I feel that it will.

■ *HT Business: In other words, U.S. chemical companies are developing and producing more end products, rather than simply selling raw materials for others to make into end products?*

POPOFF: That's a bit of an oversimplification. Companies are applying new technologies to traditional products, in order to get an advantageous position in the marketplace. But you're right. The value-added chain, even if it doesn't take you all the way to something in a box, is where the drama has been in this industry.

Dow is a case in point. Take low-density polyethylene, which has been around forever. We developed a linear low-density polyethylene that allowed people to make tougher films and use fewer pounds of film in a given application—"down-gauging" is the term the industry uses. We did not go all the way to making a finished product, something like Ziplock bags, with this particular material, but in the case of other discoveries, we did.

Those are two trends we've seen. One is adding value to an existing material through improved properties, making the product more useful to the consumer. The other is forward integration into agricultural, pharmaceutical, and consumer products, into building materials—that kind of thing.

■ *HT Business: Are there other avenues to growth?*

POPOFF: Traditionally, we've grown by our own investment in research and development, and that will remain our number-one method. We'll spend over $700 million on research and development this year. We'll also spend well over a billion dollars this year to build plants to take our inventions from the laboratory into the marketplace. That covers everything from building new facilities and modernizing and maintaining existing facilities to environmental expenditures that are as much a part of being in the chemical business as anything else. We'll also spend a bundle on marketing and sales and the commercialization of our products.

But we recognize that we have to grow in one of three ways: Through our own internal growth, through joint ventures, and through acquisition. All three are viable approaches. Joint ventures are a good idea in Japan or in other parts of the world where wholly owned investment is either impractical or prohibited by law.

■ *HT Business: So joint venture is more of a business strategy than a technology strategy?*

POPOFF: It's a strategy to either proliferate your own technology geographically, or to combine with somebody who has a piece of technology that complements what you have. For instance, a company may have a patent on a use, and another company may have a patent on the raw materials. Those two companies get together to commercialize a product.

■ *HT Business: What about acquisitions?*

POPOFF: Acquisitions are no stranger to Dow. We've made a number of acquisitions, mostly product-line extensions. We tried to make our acquisitions in the early part of the 1980s, when you could buy assets at a discount, rather than in today's environment, when assets are fully valued. Timing is a critical element.

■ *HT Business: Are acquisitions particularly risky when you're acquiring science-based companies, whose value lies mainly in the mental assets embodied by researchers?*

POPOFF: Both companies have to have common values going in. You have to have clear communications. You don't want disappointment and you don't want people feeling let down on either side. If the acquired party thinks Dow will give it funding, research, and worldwide distribution but those expectations are inconsistent with what we do, the whole thing may begin to fray.

■

"Managed in the right way, environmental scrutiny is our best ally."

■

■ *HT Business: Since last October's stock-market crash, the stocks of many small high-technology companies have been undervalued. Does that make this a particularly good time for acquisitions?*

POPOFF: From my perspective, this is no better time than any other. If a company fits with your strategy, you ought to press on. If you're looking for bargains, it's like buying a suit that's the wrong size or a pair of shoes that pinch your toes; a good buy, but not a very good fit.

■ *HT Business: What affect has growing international competition had on the U.S. chemical industry?*

POPOFF: The leading trend in the chemical industry in this decade has been consolidation. You see it first by people shutting down plants that were redundant, or selling them to people who might make better use of them. So capacity has been concentrated in the hands of fewer players. I think that's extremely healthy, because it's still a very competitive environ-

ment. The competitors are more global in nature, and companies have to develop global strategies. Companies might try to apply opportunistic strategies away from their home market in "distant parts of the world," but the world doesn't have any distant parts anymore. It's all one economy.

By and large, there are about 10 firms that are global in the full sense of the word. That means geographic presence with not just commercial but manufacturing and research capabilities, a willingness to commit to a longer-term worldwide program, and an ability to produce where appropriate, so a company is not terribly preoccupied with foreign exchange.

Over half of Dow's sales are overseas. About 45 percent of our production capacity is overseas. Our approach to overseas markets has been to export to develop a market, build a local plant to serve that local market when it's appropriate, and repeat that process with new products as they come out of research and development.

■ *HT Business: What about incursions by foreign competitors in the traditional U.S. market?*

POPOFF: As foreign firms acquire U.S. assets, they're really just doing what we've done in acquiring and building assets overseas. Ten years ago, European producers might have sold excess products at cheap prices in the United States. Now they say, "Wait a minute. I'm not going to do anything short-term, opportunistic, irrational, because I'm represented in all of these markets."

■ *HT Business: Basic science and applied research are the cornerstones of your business. How do you bridge the gap from laboratory to marketing department?*

POPOFF: That is the essence of challenge for this industry. Not considering technology in the marketing of technologically oriented products is not only a mistake initially, but it also may hamper the development of the next generation of materials. We work with teams at Dow—not because we like committees or enjoy spending hours in meetings, but because you really need a variety of inputs on some of the commercial decisions that we make. We address markets with teams of people who represent important functions or businesses. We will certainly not have all the lab guys in the marketplace; nor will we have all of the marketing people in the lab. But we'll make sure there's a good interchange between them.

■ *HT Business: So communication is the key.*

POPOFF: It's critical.

■ *HT Business: How are external factors affecting growth in the chemical industry?*

POPOFF: In the United States, the environment in which we operate is not terribly productive. Look at the time it takes from the invention of a new pharmaceutical product to its ultimate commercialization, or at the problems of operating a business in today's legal environment.

On the legal front, take tort reform. Should this be a country where you can't make a football helmet? Who cares whose plastic is going into that helmet if no one here will make one, because the chances of being sued out of your socks are so high? Tort reform is a critical consideration.

Insurance rates are also critical—a by-product of the legal system. Certainly high rates are counterproductive when compared to insurance rates in Japan or Germany or a less litigious society—and, I would say, equally safe society.

■ *HT Business: What can be done to change these largely external factors?*

POPOFF: We have several constituencies that we have to work with. We have to work together as an industry, we have to work with government, we have to address the issues with adversaries in each and every area. The environmental issues certainly need more dialogue—as someone said, more light and less heat. I think the situation in the EPA is better with Lee Thomas [administrator of the Environmental Protection Agency]. He's a tremendous manager who understands risk assessment, who understands that zero risk is not possible.

■ *HT Business: Do you think he will survive the administration change?*

POPOFF: I hope so. If Lee Thomas does not survive the administration change, I genuinely hope that he's built into his staffers some of his values and clear thinking.

■ *HT Business: The chemical industry is under intense environmental scrutiny. Do you see that changing?*

POPOFF: Managed in the right way, environmental scrutiny is our best ally. But if issues become emotional to the point where nobody cares about facts, we've got serious problems.

We're now becoming able to measure things in parts per trillion; I tell you, very little in nature measures up to that test. You can find a toxin in almost anything if you look for it at the parts-per-trillion level.

If someone says toxin X is by definition bad, and the only place we look for toxin X is in synthetic chemicals, and we find some in parts-per-trillion and disdain the fact that toxin X may exist in nature or somewhere else in greater concentrations, then we deserve what we get. What we get in that particular case is a paralysis that will cost us, not only in this industry but in all the industries that we depend on.

We've seen some of our customers atrophy, and we with them. Look at textiles. You may be the greatest textile producer in the world, but if the textile industry has gone to Asia, good luck. You may be the greatest user of chemicals in the world, but if the chemical industry is sick because of U.S. operating costs, then you have problems.

That's why our suppliers and customers are powerful allies in our getting the right story across. In the past, if something was "tainted with the worst suspicion of being toxic," everybody busted their necks to use something else. Now people are saying, "Wait a minute, I use product X as a sweetener. Can I afford to throw it out and grab something else that has less data specific to it? I want facts on my alternatives."

I submit that if you're making a dietary product and what you're using is suddenly under some suspicious kind of cloud, is it more responsible to leap to something else that's had very little testing? I think people are beginning to be more rational. DDT is bad, right? It's persistent, it hangs around. Let's find something else. Unfortunately, the first thing we found were some very toxic organic phosphorous compounds. They don't persist in the environment, but they killed a whole lot of field workers who were accustomed to going to the fields the day after spraying.

So what's bad and what's good? This is not a black-and-white world. My point is, if we could take some of the emotion out of these issues, it's relatively easy to come to a logical solution. If we become so adversarial, then I promise you we're not going to have much luck in resolving these issues. ■

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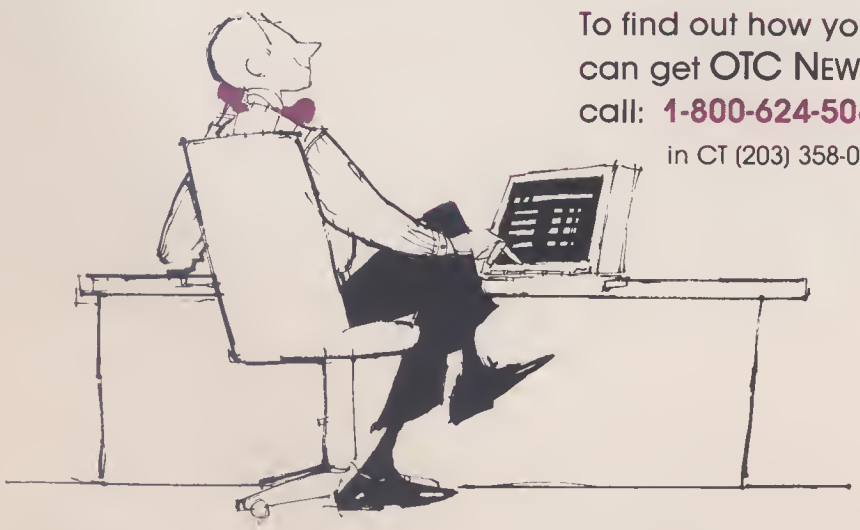

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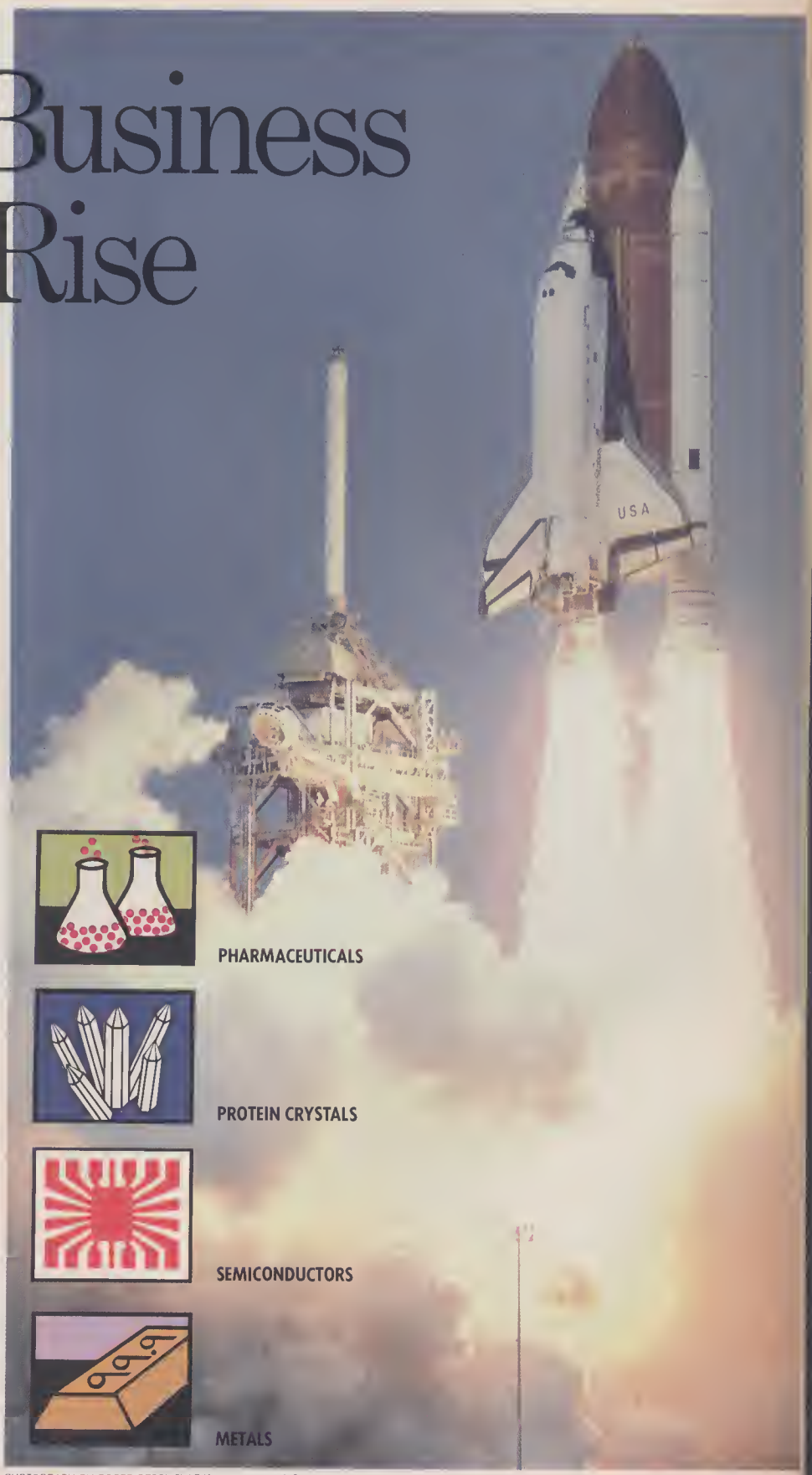
Space Business On the Rise

BY FRANCESCA LUNZER



PHOTOGRAPH BY ROGER RESSMEYER/STARLIGHT; SYMBOLS BY MICHAEL ULLRICH

IF SPACE IS the final frontier, then eager pioneers are massing at the border, hoping to send aloft experiments that will give them a competitive edge on Earth. These pioneers, some of them major U.S. companies, look to space for what it lacks: gravity. Using zero-gravity conditions, companies hope to discover ways to create new alloys, develop thin films for coatings, and grow semiconductor and protein crystals much more efficiently than they can in earth-bound laboratories.

But the stalled space-shuttle program has left these companies with no way to get their promising research into orbit. Even though the shuttle plans to fly again later this summer, the waiting list for placing experiments on the craft now stretches to five years. To satisfy the estimated 20 companies ready to do zero-gravity experiments, many smaller organizations have come forward to design those experiments, offer alternatives to the shuttle, or even establish a privately operated space station.

A space station, researchers say, could become an orbiting factory, providing

the long periods of zero-gravity needed to create alloys from metals that do not combine on Earth. Such "microgravity" factories could also produce semiconductor materials such as gallium arsenide, which grow in pure form only in space. By 1995, 10 percent of all exotic semiconductor materials will be grown in space, predicts Jeffrey Manber of the Commerce Department's Office of Commercial Space Programs. The market for earth-grown semiconductor crystals is growing at 30 to 50 percent a year and will reach $1.8 billion by 1992, according to Manber.

In the near term, however, corporate space research seeks simply to gain information, according to Leo Herbette, a founder and director of science applications at Horizon Space Products Corp., which plans to start conducting experiments in space next year. Many of the space pioneers are pharmaceutical houses that hope to send aloft experiments to produce protein crystals, which are difficult or impossible to produce on Earth. Upon their return, the crystals will be bombarded with X rays to create a "road map" for computer manipulation of the protein molecules—a way of creating new drugs (see "Designing Drugs in Space," p. 45).

Other space research involves making new alloys from metals at extremely high temperatures. On Earth, the crucible that holds the metals saps away heat, preventing certain metals from combining. But no crucible is needed in microgravity. Research will also examine how containers affect the materials they hold. For example, researchers at consulting firm Arthur D. Little have used shuttle flights to determine whether human blood is harmed by the plastic transfusion bags used to store it on Earth. Red blood cells die after a while, and the experiment aims to learn whether this may be caused by leaching of plastic from the bag, which does not occur in zero-gravity.

The next shuttle flight will carry five microgravity experiments, including a NASA stab at growing protein crystals and a 3M attempt to produce thin silicon films for semiconductors.

But the shuttle is no longer the only way for companies to get their experiments into space. This year, a program called Intospace, sponsored by the West German government, will place clients' experiments in orbit on China's Long March rockets. And next year, a company called Payload Systems expects to have its clients' experiments carried out aboard the Soviet Union's Mir space station; Payload won both U.S. and Soviet approval for the plan earlier this year.

Another company, Spacehab, wants to expand the shuttle's cargo area with a pressurized module for storing and conducting experiments. Spacehab plans to lease the module to customers, including NASA.

Business looks good for these upstarts, due in part to the Reagan administration's continued efforts to shift space development from the government to private industry. In August 1986, the administration ordered NASA to carry only its own experimental payloads, and required any company that wants NASA as a partner to pay at least half the project's cost. This privatization effort does not look temporary; both George Bush and Michael Dukakis say they support it.

■

"You could almost justify building the whole space station just for its microgravity."

—James Odom, NASA

■

Payload Systems' managing director George Economy says the decision to pursue the agreement with the Soviets came from frustration over the lack of access to space. "We should be [in space] doing experiments, not waiting on the ground," he says. Though Payload Systems won't say which organizations have negotiated to place experiments on the Mir station, the company says the first experiments will involve growing protein crystals for chemical and pharmaceutical companies.

Economy says the Soviets have been "good about not requiring us to tell them what the experiments are." But others, including the Pentagon, are worried about the security risk posed by using the Soviet station. Australian researcher Graham Laver has contracted to have the Mir station carry an experiment that seeks to grow crystals of neuraminidase, an enzyme the flu virus needs to invade the body. Laver wants to use these crystals to make drugs that will block the enzyme; his research has been funded for nearly a decade by the U.S. National Institutes of Health.

Payload Systems currently offers access to brief periods of microgravity, via flights on NASA aircraft or on unmanned sounding rockets, so clients can test their experiments. The rockets, which do not enter orbit, provide about five minutes of microgravity. The airplanes achieve 30-second bursts of microgravity, about 40 per flight.

Such testing reduces the possibility of failures, according to the Commerce Department's Manber. "The Europeans are more likely to test their experiments than we are," he says. "That's why American shuttle microgravity experiments have a 30 percent failure rate, but only 3 percent of European shuttle experiments failed."

After carrying out several successful microgravity experiments on the shuttle, 3M has begun consulting on zero-gravity experiments with other companies. However, the manufacturer has yet to sign any takers, says Christopher Podsiadly, director of 3M's science research laboratory. The company has concentrated on designing the containers that hold the experiments, and has committed to using the shuttle exclusively for the next 10 years, he says. 3M's payloads will fly for free in exchange for giving NASA research information and use of hardware.

Meanwhile, Intospace's program for placing clients' experiments in satellites carried by Chinese rockets is slated for early 1989. The satellites will orbit for eight to ten days before being recovered, says Gregg R. Fawkes, director of the Commerce Department's Office of Commercial Space Programs. Intospace, which also advises clients on the design of experiments, has booked 104 experiments on the first satellite and is negotiating with companies for a second launch, according to Fawkes.

At least two companies have pinned their microgravity hopes on the shuttle, developing ways to expand the area on the craft available for experiments.

DESIGNING DRUGS IN SPACE

The first payoff from experiments conducted in zero-gravity will involve pharmaceutical research—specifically, a look at three-dimensional images of a protein's molecular structure.

Proteins are the basis of most genetically engineered drugs, and much has been learned about them through experiments conducted on the space shuttle. But reproducing a protein calls for a crystal of that protein. Researchers crystallize proteins by mixing protein molecules taken from human cells, plants, and bacteria into a solution of water, then evaporating the water. The molecules pack together and form crystals. Those crystals are then bombarded with X rays, and the resulting images reveal how the protein's atoms are arranged.

Using computers, researchers can manipulate the X-ray image of the protein molecule to reveal a detailed image of the molecule. Drug developers then use this information to create new drugs. The U.S. Commerce Department says the market for protein crystals may be worth as much as $3 billion a year.

Not all protein crystals can be grown on earth, however, and those that can tend to be small or flawed. So far, only 300 proteins have been crystallized and analyzed, out of a potential 250,000 proteins, according to a report by Wyle Laboratories, a scientific consulting firm. Most of these 250,000 will not grow on earth.

Gravity can deform a crystal's surfaces or distribute the solution disproportionately. Earth-grown crystals "are of poor internal order, are too small, or don't crystallize at all. That's the basic bottleneck right now," says Charles Bugg, director of the Center for Macromolecular Crystallography at the University of Alabama at Birmingham, one of 16 NASA-funded research centers. Protein crystals grown without the interference of gravity can be as much as three times larger than those grown on earth, he says.

Using microgravity to produce protein crystals is still in its infancy, "but, based on what has been done and based on the theory, we feel we're going to learn a lot about the protein-crystal growth process both in space and on earth," says Bugg.

Bugg's center is working with eight major pharmaceutical companies, including Schering Plough, whose genetically engineered protein, alpha interferon, was approved to treat a form of leukemia in 1986. When the space shuttle resumes flights, it will carry solutions to grow Schering's alpha and gamma interferon, as well as other proteins.

In addition, the center will try to crystallize the human protein PNP aboard the next shuttle mission. PNP, found in red blood cells, destroys some anticancer drugs. Bugg says researchers hope to learn the protein's molecular structure in order to produce a drug to prevent its attack.

MICHAEL ULRICH

Both Instrumentation Technology Associates (ITA) and Spacehab have developed technology they plan to lease to NASA, as well as to private companies.

ITA considers one of its major assets to be its Materials Dispersion Apparatus (MDA), a semi-automated, sealed experiment chamber that holds as many as 200 samples of any two fluids. Once the shuttle reaches orbit, throwing a switch in the cockpit mixes the fluids in each experiment. ITA has tested the ability of crystals formed in the apparatus to withstand the intense stress of re-entry, a requirement whether the chamber is carried aboard the shuttle or a Long March rocket. President John Cassanto says some of the chambers can be manipulated by astronauts, others will fit into various spaces aboard the shuttle, and still others are made for use in sounding rockets. ITA also makes other experiment hardware for microgravity research, and assists companies in planning experiments.

Spacehab's tactic for expanding the shuttle's experimental legroom focuses on the mid-deck, the pressurized area the astronauts use to conduct experiments. Originally planned to hold experiments, most of the 42 lockers of the mid-deck now hold the crew's belongings and safety equipment. Spacehab wants to add to the mid-deck a module—called the Spacehab—that could hold as many as 72 lockers containing experiments. The company proposes to pay NASA between $20 million and $30 million each time its module goes up.

Spacehab president Richard Jacobson says his company has been inundated by requests from organizations that want to place experiments on the module. The costs of experiments will depend on factors such as weight, size, and the amount of astronaut time and training required. The module will fly on at least four shuttle missions, the first in 1991.

Eventually, experiments will be able to take advantage of a longer stay in microgravity conditions by shipping aboard a space station. A permanently orbiting station would feel only one billionth of the Earth's gravity, compared to the shuttle's one ten-thousandth of that pull. "You could almost justify

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Intaspace Prinzenstrasse 17 3000 Hanover 1 West Germany 05-1112-1090	Launch vehicles	Not available
Payload Systems 66 Central St. Wellesley, MA 02181 (617) 235-2465	Preflight tests, experiment consulting, and access to the Soviet Union's Mir space station	George Economy, managing director
Spacehab 600 Maryland Ave. S.W. Washington, DC 20024 (202) 488-3483	Extending research space on the shuttle, for leasing	Richard Jacobson, president
Space Industries 711 W. Bay Area Blvd. Webster, TX 77598 (703) 979-7915	Planning a commercial space station for the early 1990s	James O. Callaway, vice president
Space Services 7015 Gulf Freeway Houston, TX 77086 (713) 649-1716	Rocket-launch services	Donald Slayton, president

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

building the whole space station just for its microgravity," says James B. Odom, associate director of NASA's Space Station Office.

Until a space station is built, the shuttle's external fuel tank offers a potential alternative. The giant tank—the size of a Boeing 747's fuselage—costs an estimated $35 million to build and lift into orbit; it fuels the shuttle's booster rockets until the craft reaches orbit.

Currently, the external tank is jettisoned and destroyed as it falls back to earth. But a consortium of 57 universities called the University Corporation for Atmospheric Research has submitted a plan to reuse the tanks. The plan calls for the shuttle to cut the tanks loose while in orbit, where a company called External Tanks Corp. would manage them as laboratories or greenhouses. External Tanks, the consortium's project manager for the proposed program, has asked Congress for the rights to future external tanks, each of which offers seven times the volume of the shuttle's cargo bay.

At least two U.S. space stations have also been proposed—a smaller commercial version planned for the early 1990s, and a government station that is not set to begin construction until 1994.

The commercial space station, called the Commercially Developed Space Facility (CDSF), is being promoted by the Reagan administration and could be functioning before work on the government's space station begins—particularly if the government decides to lease space on it, at an estimated cost of about $700 million. Because Congress has referred the plan to the National Academy of Sciences for a review, a decision will probably not be made before March 1989.

Of the 10 companies interested in the commercial station, the one most likely to win government funding is Space Industries Inc. In fact, the CDSF has evolved from Space Industries' idea for a 2,500-cubic-foot module it calls the Industrial Space Facility.

Should Congress or NASA turn down the Industrial Space Facility, Space Industries will seek funding from European companies. "We wouldn't be happy about such an outcome," says vice president James Callaway, "but we'd still proceed, and we'd still make money because so many companies want to try research and development in space." The unmanned station would fly 200 miles above the earth in the same orbit as NASA's station. Shuttle crews would visit it every few months to deliver, maintain, and retrieve experiments.

Considering the current launch costs, unmanned orbiting vehicles may represent the only way to perform cost-effective manufacturing in space, says Robert Naumann, acting director of NASA's Microgravity Science and Applications Division. The microgravity pioneers will probably not see a quick payoff from their experiments, he adds, "but it could come if we find that improvements in the quality of [protein] crystals can be gained."

Many of the companies involved in microgravity research, however, are not seeking quick or even quantifiable payoffs. One example: Arthur D. Little's experiments with blood-transfusion bags. "Finding out what effect the plastic has on red blood cells and how long the cells stay alive in a nongravity environment will improve blood collection and storage methods, and ultimately save lives," says Peter Glaser, vice president of space operations. "Is there any way to put a price on that?" ■

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Mini-Supercomputers

Clash of the High-Speed Titans

Market leaders Convex and Alliant fend off challengers

BY MICHAEL R. LEIBOWITZ

YOU'D THINK someone could make a couple of bucks in the mini-supercomputer business. After all, these refrigerator-sized electronic boxes carry price tags of $100,000 to $1 million, cost only about one third of that to produce, and have customers clamoring for them. Mini-supercomputers give scientists and engineers the power to tackle such tasks as creating chemical compounds, test-crashing automobiles, and pinpointing underground oil, all at the stroke of a key. Everyone agrees that the market is going to be big, and that in this early, high-growth stage someone should be making a bundle.

But at the moment, no one is making much money in the mini-supercomputer business, and a lot of people are losing money. An influx of new competitors in the three-year-old, $350-million annual market has spawned an all-out war, with companies sometimes all but giving away products to close important sales. The reasoning is "market share at all costs," says George Weiss, an analyst with the Gartner Group.

It's an expensive way to do business. The number-two player, Alliant Computer Systems Corp., has given up most of its profits, eking out a meager 0.5 percent operating margin, or $71,000 on sales of $13.6 million last quarter. Just one year earlier, the company celebrated a record quarterly operating income of $2.25 million, a handsome 19 percent of its $12 million in sales. Although market leader Convex Computer Corp. is faring somewhat better, it still had only a 5 percent operating margin last quarter—earning an operating income of $1 million on sales of $22.1 million—down from a 10 percent operating margin a year ago. Meanwhile, most of the other contenders are bleeding red ink.

Few expect the cutthroat fighting to end soon. "We're assuming that the industry, and we, are in for some tough times over the next few quarters," says Ronald H. Gruner, president of Alliant. Both Alliant and Convex have ample cash reserves to help them weather the next 12 months. But a second tier of companies, including Multiflow Computer, Cydrome, and Scientific Computer Systems, is much less secure. Industry observers expect some of the newcomers to fall by the wayside.

But the fighting won't stop then. By the time this current round of skirmishes ends, survivors will have to square off against the most formidable competitor as it lumbers into the mini-supercomputer market sometime in 1989: Digital Equipment Corp. DEC refuses to discuss product plans in advance, so observers can only speculate on what form that entry will take.

Few people realized how hot the battle would become when Convex, then a two-year-old startup, announced the first stand-alone mini-supercomputer in the fall of 1984. The idea behind the product was to give engineers and scientists a specialized machine that could inexpensively run very complex programs, such as simulations. Instead of shelling out $2,000 an hour to share time on a Cray supercomputer, or tying up an entire department's DEC VAX super-minicomputer for days, researchers and designers can now have their very own mini-Cray, for about $500,000.

Mini-supercomputers were an instant hit. Universities and government research labs grabbed the first ones, undaunted by the lack of software or by

ILLUSTRATIONS BY SHARON DRINKWINE

the fact that they were made by a then-unknown company. These early buyers could throw legions of graduate students at the task of converting software to run on the new machines.

Six months after Convex, Alliant jumped into the fray, introducing a machine that offered higher performance because it used a unique architecture consisting of several processors operating at once, in parallel.

Flocks of entrepreneurs and investors were lured to the market by the early success of Convex and Alliant, and also by analysts' projections of a $1-billion market by 1990. In 1984 and 1985, no fewer than eight companies began designing mini-supercomputers. Lack of cash or product-development blunders soon drove five of them out of business. Among those that survived, start-up Scientific Computer Systems began shipping its mini-supercomputer one year after the Convex introduction. Multiflow, founded by three Yale professors and backed by $42 million in venture capital, began shipping its machine last year. Cydrome, supported by $39 million and a partnership with established minicomputer-maker Prime Computer, shipped its first machines in January of this year.

Today, these companies share the mini-supercomputer market with about a dozen fringe players—companies such as Floating Point Systems, Elxsi, Intel, and Stellar—whose products appeal to particular segments of the mini-supercomputer market. That market will reach $344 million this year, up 43 percent from $240 million last year, according to the Gartner Group. In 1989, sales should swell to $480 million and continue steady growth to $1.2 billion by 1992, predicts Gartner.

That's respectable growth, but less than what the industry was banking on. Planners and executives assumed that mainstream commercial and industrial customers would embrace mini-supercomputers as fast as universities and research labs had. But businesses are far less adventurous. Many were unwilling to accept a shortage of ready-to-run applications software, and others worried that upstart manufacturers might not exist tomorrow.

As a result, mini-supercomputer makers are scrapping for each piece of business in a market that's two-thirds of the size they expected. "They're meeting each other in the waiting rooms of the key accounts," says Gary Smaby, an analyst with Piper, Jaffray & Hopwood. Discounts of 25 percent are typical, according to Alliant's

Gruner. For strategic accounts—buyers Gruner calls "opinion leaders"—prices get slashed in half.

That's because opinion leaders can generate a lot of business. Once a mini-supercomputer gets installed at a major auto company or aerospace manufacturer, software companies will adapt their programs to run on the machine because they expect the machine to become a standard in the opinion leader's market segment. With software readily available, other companies in that segment are more likely to buy the mini-supercomputer of choice. Thus the computer maker can establish a lock on a market segment.

Mini-supercomputer makers also discount heavily to get their machines into large accounts that may buy more equipment later. Often, a renegade group in a *Fortune* 500 company breaks the ice, and other departments in the company follow. If you can get in the door, "you have much higher odds of winning the next procurement without discounting," says Jeffrey Canin, an analyst at Hambrecht & Quist.

But perhaps the biggest reason to offer discount prices is the looming presence of Digital Equipment. General consensus holds that when DEC joins the race in 1989, as expected, its strength as the dominant computer supplier to engineers and scientists will quickly propel it to the top of the mini-supercomputer market.

As a defense, Convex and Alliant are trying to beef up their base of installed machines "so they can compete against the better financed and established giant," says Canin. The two companies have sold respectable numbers of machines, and each quarter they announce a new milestone in sales. As of April 1, Convex had installed 303 systems, and Alliant had shipped 239.

These two companies appear to be the only sure bets to survive the next 12 months. Each has cash reserves in excess of $63 million, plus enough momentum to stay in the lead. Further, evidence suggests that Convex and Alliant are drawing lines to temper some of their head-on price battles. Convex's new products due to ship in the fourth quarter lean toward the high end of the mini-supercomputer market, an area in which Alliant does not compete strongly. Also, analysts expect both companies to land a number of follow-up buys from customers, which should reduce the amount of discounting.

Still, both Convex and Alliant have lists of things to do before Digital attacks. Convex is gunning for more accounts and signing up more third-party software suppliers to write programs for its machines; the company already boasts more third-party software than Alliant. However, analysts say Convex must worry about customers holding up orders in anticipation of its second generation of products, due to ship late this year. Some speculate that Convex may also face stiffer competition in international sales, which account for about half of its business. Alliant is targeting the international market for the first time this year.

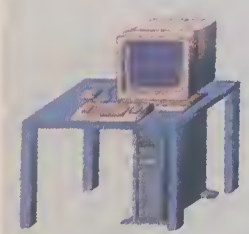
To do so, however, Alliant must establish an international sales operation from scratch. The company recently ended an international-distribution agreement with Apollo Computer that had set sales targets that were too low, causing Alliant to cede most of the Eu-

A FIELD GUIDE TO COMPUTERS

Increasing performance and decreasing prices are blurring the traditional distinctions between types of computers. Some personal computers cross into the performance range of computer workstations, and expensive workstations are assuming the power of lower-priced minicomputers. A new class of machines—highly parallel computers—overlaps several categories.

To clear things up, here's the HIGH TECHNOLOGY BUSINESS *guide to computer categories.*

PERSONAL COMPUTERS General-purpose desktop computers that use 16- or 32-bit microprocessors (the more bits, the faster a computer works). Price: less than $1,000 to $5,000.



WORKSTATIONS High-performance 32-bit computers used by engineers, scientists, and technical professionals who need superior graphics. Workstations, commonly used in computer-aided design, offer the performance of minicomputers but serve one person. The station often sits on or beside a desk and connects to other workstations in a network. Price: $5,000 to $100,000.

MINI/SUPER-MINICOMPUTERS Minicomputers have largely been supplanted by more powerful super-minicomputers. Machines in this category can handle the general needs of more than 100 people, who typically work on terminals wired to the computer. Super-minicomputers are about as big as a two- or four-drawer filing cabinet; several often connect to form a company-wide network. Increasingly, such networks are replacing mainframes. Less powerful minicomputers: $20,000 to $100,000; super-minicomputers: $100,000 to $1 million.

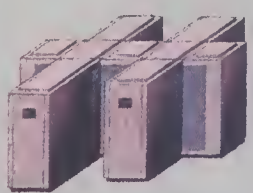
MINI-SUPERCOMPUTERS Computers that handle complex math computations for engineers, scientists, and researchers. Because of basic differences in design, mini-super-

THE MINI-SUPERCOMPUTER COMBATANTS

COMPANY	CEO	FOUNDED	1987 REVENUES	1987 NET INCOME	PROSPECTS
Convex Computer 701 Plano Rd. Richardson, TX 75083 (214) 952-0200	Robert J. Paluck, president	October 1982	$69.6 million	$8.8 million	Generally considered the best positioned to weather the market battle. Has sold the most systems by far and has the largest list of compatible third-party software, plus a strong balance sheet. Will probably hold first place until DEC enters the market in 1989.
Alliant Computer Systems 1 Monarch Dr. Littleton, MA 01460 (617) 486-4950	Ronald H. Gruner, president	May 1982	$53.8 million	$6.9 million	Well positioned to retain second place. Had a rough first quarter and losses could lie ahead, but has $64 million in cash, a large installed base of systems, and a large list of compatible software. Expected to emerge from the fray in good shape.
Multiflow Computer 175 North Main St. Branford, CT 06405 (203) 488-6090	Donald E. Eckdahl, president	1984	Not available (private company)	Not available	Enjoys innovative technology, experienced management, and immediate product acceptance. With investors beating down its doors, seems to have access to the finances needed to establish itself over the long term. Considered the most likely of the latecomers to succeed, moving in behind Convex and Alliant.
Scientific Computer Systems 10180 Barnes Canyon Rd. San Diego, CA 92121 (619) 546-1212	Barry Rosenbaum, president	October 1983	Not available (private company)	Not available	Prospects mixed as it emerges from what SCS executives call a "restart phase." A new focus on the Cray-compatible market segment should lend staying power, but SCS may not have access to funds needed to make this strategy work.
Cydrome 1589 Centre Point Dr. Milpitas, CA 95035 (408) 945-6300	Andre O. Schwager, president	May 1984 (founded as Axiom Systems)	Not available (private company)	Not available	Fate seems to depend on how well Prime Computer executes its agreement to sell Cydrome's machines, which are good but not exceptional. Suffers from late entry, a small installed base, and little compatible software. Faces same challenge as the other private companies: keeping the doors of the investment community open long enough to establish profitability.

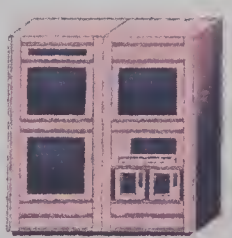
SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

computers outperform conventional computers in vector processing—simultaneously performing calculations on different lists of numbers. About the size of a refrigerator, mini-supercomputers deliver a quarter to half the performance of a supercomputer at only one-tenth the cost. Price: $100,000 to $1.5 million.



MAINFRAME COMPUTERS Large, general-purpose computers that serve hundreds or thousands of users, all tied to a corporate data-processing center. A typical mainframe is slightly smaller than a Volkswagen Beetle and requires an atmospherically controlled room. Mainframes generally handle the major data-processing needs of large corporations, such as the weekly payroll. Despite encroachments by networks of super-minicomputers, mainframes remain the staple of large data-processing centers. Price: as much as $5 million.

SUPERCOMPUTERS The world's fastest computers, used in science, engineering, and research for the most difficult processing challenges, such as weather forecasting. An average supercomputer is no larger than a mainframe, but packs faster processors that are more closely connected, to provide greater computing speed. Several companies or organizations often share time on one supercomputer to offset the high cost of these machines. Price: $2.5 million to $25 million.



HIGHLY PARALLEL COMPUTERS A new type of computer that uses 16 to 64,000 processors (by comparison, mini-supercomputers and supercomputers have one to eight fast processors). The processors divvy up and independently work on small chunks of a large problem. Parallel computers excel at programs with many independent operations that can be done at the same time; they match the speed of supercomputers at a fraction of the cost. However, due to programming difficulties, highly parallel computers have yet to break into the commercial and industrial markets. So far, their primary customers have been universities and research institutions. Because supercomputers are inherently limited in how fast they can get data from memory, parallel machines—which put memory in each microprocessor—may become a better-performing alternative. Price: less than $100,000 to $7 million.

WHO USES MINI-SUPERCOMPUTERS?

Mini-supercomputers are used mainly by engineers, scientists, and researchers who must solve problems too complex for standard data-processing computers, but who don't have enough funds to buy an ultra-expensive supercomputer. However, virtually any company involved in complex research or design could benefit from mini-supercomputers, because the powerful machines allow simulations—an increasingly popular way to test ideas before sinking time and money into building prototypes or performing experiments.

Companies that make computer chips use mini-supercomputers to simulate the operation of the hundreds of thousands of transistors crammed onto integrated circuits. Aerospace and automobile designers use the computers to simulate the effects of wind passing over the surface of a car or a jet wing, creating a sort of digital wind-tunnel.

Other automakers, such as Nissan, test the crash-worthiness of new car designs by smashing a computer model of a car into a simulated wall. After reviewing the test results, engineers can alter the design, then simulate the crash again to see if their changes work the way they thought they would. In addition to saving cars and time, simulations let designers try more ideas than they can when crash-testing actual vehicles.

Chemistry is one of the fastest growing fields for mini-supercomputers. Pharmaceutical companies such as Merck and Bayer and research organizations such as the Scripps Institute use them as a digital chemistry lab, substituting simulations for physical experiments. In addition, film and video production studios use mini-supercomputers for computer animation, civil engineering firms test bridge designs on them, and military contractors buy them to control Strategic Defense Initiative systems.

ropean and Japanese markets to Convex. Alliant must also get more software companies to write programs for its machines. Finally, the company must increase its penetration in the all-important mainstream commercial sector, an area in which it has been less successful than Convex.

Tremendous price pressure will hit Alliant harder than it will Convex, because Alliant concentrates on the products that sell in the more competitive $100,000 to $300,000 range. Alliant may also suffer more revenue and earnings pressure as buyers, confronted with a greater choice in lower-cost mini-supercomputers, take longer to make up their minds.

Among the newer contenders, Multiflow is considered the leader for third place behind Convex and Alliant. Its mini-supercomputer, which uses novel hardware and software technology that purportedly boosts performance and minimizes the need to rewrite programming, has met an outstanding reception. In its first nine months of production, Multiflow shipped more than 30 machines. "We're selling the right quantity of product to the right people," says Joseph Fisher, executive vice president and co-founder.

However, analysts warn that Multiflow must maintain the capital resources necessary to build its marketing and sales organization and follow through on second-generation products. Based on its technology and the experience of its management team, "I would give them a better-than-average chance of success," says Gartner Group's Weiss.

Observers are less excited about Cydrome, whose products are not considered revolutionary enough to have an impact in a market that has been maturing for three years. However, one Cydrome asset is its partnership with Prime Computer, under which Prime sells Cydrome's machine internationally and in part of the U.S. market. In fact, Cydrome delayed the introduction of its computer for six months to help Prime ramp up its sales effort, according to Cydrome president Andre Schwager.

However, observers question whether the Prime connection is enough to offset Cydrome's late entry. "You've got two established vendors out there that have market dominance," says Smaby of Piper, Jaffray. "It's going to be tough to come from behind."

Scientific Computer Systems (SCS) may finally have a winning strategy, but experts wonder if it may already be too late. The private company lost untold millions trying to battle Convex and Alliant before luring away Barry Rosenbaum, the former Convex marketing vice president responsible for that company's successful international effort. Once at the helm as SCS president, Rosenbaum overhauled the company, refocused its marketing strategy, hired new salespeople, and raised more than $5 million in venture capital to keep going.

SCS is now aiming for a narrow segment of the mini-supercomputer market: users of Cray supercomputers who would like to run their programs on a smaller machine. To satisfy that yen, SCS offers Cray-compatible mini-supercomputers. "We see very little competition in the Cray-compatible market," says Rosenbaum.

Analysts think this strategy may work, if SCS can muster enough capital resources to hold on until it makes it into the black. "They have a steep hill to climb," admits Canin of Hambrecht & Quist, adding, "I'm more hopeful than I've been in the past."

While the battle looms for third place—and for many lesser companies, for survival—Digital waits in reserve. Few doubt that DEC will walk away with the biggest share of the market. But for Alliant, Convex, and any other company that can secure a healthy slice of the market today, DEC's entry could represent an opportunity.

"DEC will do for us what they've done for Sun," says Convex president Paluck, referring to Sun Microsystems, the leading maker of technical workstations. Sun has experienced booming growth despite Digital's entry into the workstation market several years ago. Paluck expects Digital to legitimatize the mini-supercomputer and attract customers who were undecided. When Digital enters, he says, "the overall accessible market explodes. It explodes into the billions." ■

Michael R. Leibowitz is a business writer who specializes in the computer and electronics industry.

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BIOTECHNOLOGY

APPLIED GENETICS NEWS

Coming: New Monoclonal Antibodies

With more than 100 products now on the market which are based on monoclonal technology and already achieving revenues in the neighborhood of $300 million annually, the next step is the next generation of monoclonals.

The first-generation monoclonals have found application mainly in diagnosing and treating disease. They have been used for their ability to bind antigens. The role of the second-generation monoclonals, known as anti-idiotypes (anti-ids), would be to mimic the shape of a variety of molecules. Anti-ids could serve in a wide range of important applications, with possible uses in improved vaccines, drugs, and enzymes.

A number of companies are already active in anti-id research. Among the large pharmaceutical companies involved are Ortho Pharmaceutical, Merck, and Hoffmann-La Roche.

At least a dozen biotechnology companies are also involved, along with such well-known companies as Eli Lilly's Hybritech and Centocor. Smaller companies include Biotherapy Systems and Biotherapeutics.

Much of anti-id development has been related to or focused on development of vaccines that might be effective against the AIDS virus. While many companies won't spell out their activities in this area, some will. Synbiotics is devoting $11 million to anti-id research, including a $3.5-million joint-development agreement with International Minerals and Chemicals for veterinary applications. Synbiotics is also developing two anti-id animal vaccines that it expects to market in 1991, one against feline infectious peritonitis and the other against canine heartworm disease.

The anti-id technology that could influence the development of new products centers around mating a monoclonal with a monoclonal. Antibodies, including monoclonals, are made of white blood cells, the B lymphocytes, which are part of the immune system. Antibodies bind to antigens on disease-causing organisms—or pathogens—such as viruses, marking those organisms for destruction.

In a hypothetical example, a monoclonal to work against an antigen would be shaped like that antigen, and a monoclonal to work against a monoclonal, an anti-id, would also mimic the shape of the antigen. Thus, the anti-id could spark antibody activity without actually being part of the pathogen.

That factor could be key to making safer vaccines. Conventional vaccines make use of actual pathogens, which are either killed or genetically weakened so they will not cause disease. The problem with conventional vaccines is that they sometimes fail, either because the pathogen has not been killed or because it has not been sufficiently weakened. Use of anti-ids might solve that problem. Since the anti-id mimics only the antigen of a disease-causing organism, the anti-id could cause antibody production without the risk of inadvertent infection.

Anti-ids are being studied for use in fighting autoimmune diseases. There is conjecture that rheumatoid arthritis may result from antibodies attacking connective tissue of the joints. In theory, autoimmune antibodies could be isolated and anti-ids

CONTENTS

made against them. The anti-ids would then bind to the autoimmune antibodies, rendering them harmless.

Cancer is another potential target for anti-ids. Idec and Biotherapy Systems of Mountain View, Calif., are developing anti-ids to fight B-cell lymphoma, a cancer of the B lymphocytes. Those cells not only make antibodies but also place a copy of those antibodies on their outer membrane. Antibodies could be isolated and anti-ids raised against them. Then, bound to the antibodies, anti-ids could mark cancer cells for destruction.

The design of drugs that interact with cell-membrane receptors is also possible. Researchers use receptors in the lab to screen for new drugs, but receptors cannot always be isolated from cell membranes. With anti-id technology, an antibody could be made to a receptor.

So the possibilities are numerous—yet another area for research and development.

Tool Produced for Developing AIDS Inhibitors

Genetics Institute has entered into a collaborative arrangement with the National Institutes of Health (NIH) to investigate the important viral enzyme reverse transcriptase. This is a step that could help pave the way for new, less-toxic therapies for persons with AIDS.

Scientists at Genetics Institute are already producing a genetically engineered form of reverse transcriptase, an enzyme that enables the HIV virus to infect cells. The company is supplying quantities of recombinant reverse transcriptase to researchers at the NIH and has the right of first negotiation to commercialize any reverse-transcriptase-based anti-AIDS product that emerges from this work.

Reverse transcriptase is a critical component in the chemical machinery of a class of viruses, including HIV, called retroviruses. Reverse transcriptase is used by the viruses to enable them to take up residence within infected cells where the virus can either reproduce itself rapidly or lay dormant, perhaps for many years.

The primary goal of the current research project with reverse transcriptase is to create a drug that would act specifically on the HIV virus. A major drawback of therapies using existing drugs is that although they are effective at inhibiting viral reverse transcriptase, they also interrupt the action of normal cellular enzymes and can thus be severely toxic. A drug that acts more specifically on reverse transcriptase should have fewer side effects.

Genetics Institute scientists are collaborating with seven NIH research groups working to define the relationship between the structure and functions of reverse transcriptase, using such techniques as two-dimensional nuclear magnetic-resonance spectroscopy, chemical modification, and enzymology.

The data collected will be used to aid in the identification of an inhibitor of the enzyme, and hence of the HIV virus itself. The collaboration falls within the NIH to improve upon drugs that inhibit the viral enzymes.

The arrangement with the NIH expands an existing Genetics Institute/Harvard University collaboration to map the three-dimensional structure of the HIV reverse-transcriptase molecule.

SUPERCONDUCTIVITY

The Cambridge Report on SUPERCONDUCTIVITY

New Method to Measure Meissner Effect Hailed

Superconductivity (SC) researchers racing to improve upon existing high-temperature SC materials continue to struggle with twin problems. The first is demonstrating and measuring the effects of the expulsion of a DC magnetic field, especially on very thin films of superconductors deposited on thick heavy non-SC substrates. The second is verifying claims of room-temperature SC.

But a simple method based on a new magnetic measurement approach has been conceived to both verify and quantify the DC Meissner effect in essentially any superconductor at any temperature, and one company is developing a product based on the approach.

Basically, the material to be tested is suspended from a support by one or two line filaments having a convenient and accurately measured length. The

filaments must be non-magnetic. Mono-filament (fishing line) polyester a few millimeters in diameter is suitable.

A reticle-calibrated microscope is then focused horizontally on the filament, a short known distance above the sample. A permanent magnet, whose field strength has been determined (versus distance from the magnet) by a flux meter, is then brought horizontally (at a right angle to the microscope axis) to a desired distance from the sample.

The DC Meissner effect will cause a deflection that can be easily observed and measured through the microscope. A movement as small as a few micrometers (microns) is easily observed.

As an example, if the filament suspension is 20 cm long and a deflection of five microns is measured when the magnet is brought toward the sample, the Meissner force on a one-gram sample is only 25 micrograms. This sensitivity will be enough to show and measure the Meissner effect even if the sample comprises a very thin SC film on a thick, much heavier substrate.

Looked at in another way, the Meissner effect will be observed and measured even if less than 0.01 percent of the material is SC.

This method can be used to observe and measure the direct DC Meissner effect versus temperature, magnetic-field strength, and repeated cycling of these variables. Temperature can be measured by remote infrared methods or, if two conductive filaments are used, by a thermocouple mounted on the sample. In the latter case, the weight of the sample must include the thermocouple.

It should be clear now that the new method is a first cousin to the string galvanometer of the nineteenth century. Both the almost-forgotten string galvanometer and the new method described here are capable of high sensitivity and accuracy.

Bismuth Compound Offers Semiconductor Advantages

Just as growing numbers of scientists were concluding that the copper-oxide compounds at 90° K critical temperature are as good as superconductivity gets, along comes the next wave of significant improvements.

While the new material formulated at the National Research Institute for Metals in Japan and the University of Houston seems at first glance only a slight incremental increase over the 1-2-3 compound—from 90° K to as much as 120° K—the significance of the advance extends far beyond temperature. In the new material, copper remains the majority metallic element, joined by bismuth, strontium, and calcium (aluminum is apparently unnecessary), as follows:

$$Bi_2Sr_2Ca_1Cu_2O_{8+X}\ (X=0.15 \text{ to } 0.2)$$

The advance eliminates rare earth elements.

Here are some of the potential issues:

Reproducibility. Scientists have encountered obstacles in reproducing other reported advances in high-temperature superconductivity (HTSC), but more than a dozen labs quickly replicated this latest compound. Discrepancies exist as to the exact temperature at which the compound becomes superconducting.

Production. Corporate researchers we have interviewed say that the new material is easy to produce and "more forgiving" than the 1-2-3 compound. It retains oxygen, whereas rare-earth-based HTSC materials don't. It also appears to withstand humidity, unlike the 1-2-3 compound.

Critical current. The current-carrying capacity of the bismuth-containing materials isn't yet known. Potential applications of the 1-2-3 compound have been limited by the low critical currents achieved thus far (in bulk, but not in thin films), although advances have been reported. The higher SC temperature of the net material should allow higher critical current at 77° K, the temperature of liquid nitrogen.

Economics. The new material is fabricated from common and inexpensive materials. The yttrium in the 1-2-3 compound is at least 10 times more expensive than any component of the new compound. Until the bismuth-containing compound is perfected, the fate of the 1-2-3 compound is uncertain.

Applications. The comfortable difference between the temperature of liquid-nitrogen coolant and the critical temperature in the new compounds may well increase activity in adapting wires and cables to electric motors, instruments, and magnetic separators, among other applications.

Superconducting theory. Ever since development of the 1-2-3 compound a year ago, scientists have struggled to understand the theory behind its SC capacity. Du Pont researchers now say they have identified the structure of the bismuth-containing compound and isolated the SC part.

ANDREW SEYBOLD'S
OUTLOOK
ON PROFESSIONAL COMPUTING

OS/2 Represents Future of Micro Operating Systems

At a seminar earlier this year, IBM and Microsoft representatives discussed the merits of OS/2 and OS/2 Extended Edition at length. In addition, both companies stated that, by year's end, more than one thousand software applications would be available for OS/2 from the industry as a whole. In the course of things, IBM also talked about DOS 3.X and its relationship to OS/2, as well as about the future of DOS. This article is meant to give you a sense of what went on at the seminar and some perspective on the larger picture.

The version of OS/2 that's available today from IBM and others is termed the "Standard Edition." The first step in the progression of the product, version 1.0, is available now from IBM, Compaq, and several other hardware vendors. Each vendor's implementation of OS/2 is slightly different from the others', and it isn't yet clear whether compatibility problems will arise as a result.

OS/2 Standard Edition Version 1.0 includes the base operating systems, the ability to run DOS applications (one at a time, and with some problems running DOS communications or other types of programs that require clock access).

Standard Edition Version 1.1, which is scheduled to be delivered before year end, will include the Presentation Manager, a "graphical" user interface. The Presentation Manager will be available in October 1988, followed by the balance of the Extended Edition add-ins and add-ons.

Standard Edition Version 1.1 will be the "final" product offered by Microsoft (according to both IBM and Microsoft representatives). But it will be only one of the products offered by IBM. OS/2 Extended Edition Version 1.0, an IBM-priority product that will be offered by IBM only, will include OS/2 Standard Edition and the Presentation Manager, as well as the following: a relational database manager, Structured Query Language (SQL), end-user facilities, a communications manager, concurrent communications, multiple connectivities, protocols, and emulators, and network-management capabilities.

There's one other module coming from IBM. It is the LAN server, which will be needed if OS/2 is to be used effectively as a local-area network server.

The current version of OS/2 provides the ability to run multiple OS/2 applications concurrently and breaks the 640K memory barrier. It also allows one DOS application at a time to be run in "compatibility mode."

IBM's implementation of this first version of OS/2 runs on all 80286- and 80386-based IBM-made systems that are equipped with at least 1.5MB (more realistically 2M if DOS applications are to be run). IBM's installation manual also states that 5M of hard-disk space must be available.

IBM's hardware recommendations for OS/2 include 350K to 500K per application (if you want to run four applications all at the same time, multiply this by four). The minimum hard disk recommended is a 20M unit with at least 1M held in reserve as a virtual-memory "swap file," and, of course, EGA or VGA display equipment. In addition, IBM recommends having at least 3M of RAM.

Our initial tests with IBM's version of OS/2 show that it won't run "out of the box" on most non-IBM machines (we tested it on the Xtra Professional Series 386, the Compaq 386/20, the Tandy 4000, the AST Premium 386, and the Wang 386 but could not get it to install on any of these systems).

Our understanding is that the IBM version of OS/2 Standard Edition looks for a specific symbol within the ROM BIOS and won't install itself if it fails to find what it's looking for.

At the seminar, IBM was asked directly whether OS/2 Standard Edition or OS/2 Extended Edition were designed specifically to run on IBM machines only. The company's answer was no. In responding, IBM made the point that it is in the software business and said that it has done nothing "special" to inhibit its version of OS/2 from running on any 80386- or 80286-based system.

Both IBM and Microsoft make some important distinctions between OS/2 and DOS. IBM considers DOS an independent-function, single-application operating system that supports a moderate amount of random-access memory. IBM defines OS/2, by contrast, as a multiple-application integrated environment, with expanded memory requirements.

In general terms, OS/2 was built to take advantage of the power and speed of the Intel 80286 and 80386 processors, to overcome the 640K

memory barrier, and to facilitate true multitasking.

In looking closer at the differences between the two operating systems, it makes sense to divide OS/2 into six segments, each of which has been designed to provide capability and flexibility that far exceeds what's available in DOS.

The memory-management segment provides for very large real-memory addressing (up to 16M or more), and for virtual memory—the swapping of program segments, programs, and files in and out of real memory on an as-needed basis. The task-management segment handles the multitasking of applications as well as inter-process communications.

The program-management segment provides dynamic-link libraries, session control, and an extendable call interface. The device-management portion of the system handles device independence, the overlapped input/output structure, and IOPL.

The user-interface management portion includes the Presentation Manager, which provides a graphical user interface and windowing capability. Finally, the file-management system provides support for large files and handles the partitioning of information storage and retrieval.

IBM stresses that DOS and OS/2 can and will co-exist in the same environment, and, in fact, on the same machine. Facilitating such coexistence is the fact that the data files of both systems are fully compatible. In addition, many of the basic commands of the two operating systems are the same, although OS/2 has various new commands and requirements. For example, the printing function is different under OS/2 (because of the addition of the spool command), some OS/2 batch files run in protected mode, and the serial-device management is also different.

At the seminar, IBM presented some interesting test results. Performed for IBM by an independent testing laboratory, the tests were developed to measure the relative throughput of DOS and OS/2. Throughput, after all, is the name of the game—how quickly is a process completed and, more important, how fast can users get from the beginning of a task to the point where they're free to move on to the next one?

The activities measured included running DisplayWrite 4, outputting information to a serial port (a modem), doing a print test, running random input/output routines, and using XCOPY to copy files between file areas. Run on an IBM Model 80, the tests showed that under DOS 3.X, the foregoing tasks took 465 seconds to complete. Under OS/2, the same tasks were accomplished in 181 seconds—61 percent faster.

In evaluating the significance of these figures, remember that the tasks just described were handled simultaneously under OS/2 and that IBM did not measure the setup time required to get all these actions to run in multitasking mode. Even so, the results are indicative of the advantages of multitasking in an office environment where the typical tasks a computer performs involve working with data, outputting it, working with other data, and outputting that.

Bear in mind also that these tests were performed to promote OS/2 in the corporate environment. We do not take issue with the results or the findings. Nevertheless, we think it's worth remembering that although the tests were performed by an independent lab, the premise under which they were run was that OS/2 was better and faster than DOS.

Fujitsu Method Will Make Laser Printer Smaller

Fujitsu Laboratories has developed a recording method that leads to improved reliability and a dramatic reduction in the size of laser-beam printers. Compared with the existing Carlson-type printing method, the new technology, called the optical rear surface recording method, reduces the printing process from seven steps to four.

The Fujitsu method makes electrical charging, exposure, and developing into one step and eliminates the cleaning step from the total process. The remaining three steps—transfer, fixing, and removing the electrical charge—are the same as in the Carlson method. Also, the voltage requirement for giving a uniform electrical charge has been reduced from 8,000 volts to 400 volts.

Because of the simplification of the printing processes, the size of the printer can be reduced by 30 percent. Moreover, the lowering of the voltage requirement has made the printer safer and

reliability higher. An ozone filter required in conventional laser printers is not needed because the lowering of the voltage prevents the generation of the harmful gas.

The process of cleaning residual ink (toner) was eliminated by devising a system where the developer would electrically recover 100% of the residues and recycle them to be used again. The researchers noted that the new laser printer may be commercially introduced in two to three years.

SUPERCOMPUTING

INTERNATIONAL COMPUTRAN CORPORATION TEC REPORT

Optical Neural Computer Has Associative Memory, Learning Ability

The Institute of Industrial Technology and Hamamatsu Photonics have jointly developed a prototype optical neural computer said to be the first of its kind that runs without programs. Designed mainly for imaging tasks, the computer "studies" images and produces an image that resembles the input.

The Optical Association computer uses a 4×4 light-emitting diode to create simple characters or graphics. From the images stored in its memory, the computer produces an image that most closely resembles an input image. During the initial stage while its memory is incomplete, the computer will output any image at random. It will then compute differences between the output image and the input and gradually revise its stored image until it produces the correct image.

Once the computer perfects the image, it will output a complete image even if the input image is defective. For example, if the character "A" is entered with part of the character missing, the computer, through its associative-memory function, will be able to recall the image of the total character and output the complete character.

Researchers indicated that they hope to eventually develop an intelligent sensor system that will function as human visual and tactile senses do.

Japanese Lab Develops Flow-Type Parallel Processor

The Industrial Technology Agency's Electrotechnology Lab has announced the development of a non-von Neumann-type parallel processing computer touted as the new generation of supercomputer.

Unlike traditional von Neumann-type computers, the new development, called Sigma-1, is a data-flow-type parallel-processing system that divides a complex scientific computation into many segments and produces an answer at ultra-high speed. The Sigma-1 consists of 128 arithmetic processors and 128 microprocessors that store and read data using the data-flow method.

Traditional von Neumann-type computers process data sequentially, one process at a time. The new-generation system processes many parts of a computation in parallel.

The data-flow computer has a maximum processing speed of about 640 MFLOPs, or about 1.7 times the speed of an average supercomputer. Moreover, the computer is made up of conventional CMOS devices, proof of the superiority of the data-flow concept over the von Neumann machine, researchers said.

The laboratory said that, after a year of evaluation tests, the computer will be publicly available through telephone lines.

SEMICONDUCTORS

SEMICONDUCTOR ECONOMICS REPORT

Technical Issues Slow Arrival of Four-Megabyte Memory Chips

Even though the industry is currently only worried about where to get a supply of 1-Megabyte parts, a key question for planning purposes is, when will the 4-Meg devices be readily available? After introductions in early 1987, it appeared that a late-1988 production schedule would occur, thus shortening the normal life of the 1-Meg part by a year. For the leading vendors, this made sense—

establish an early position and use the production "experience" curve to improve yields and costs and to maintain the earlier high profit margins. That scenario would have also eliminated more of the competition, especially in the United States.

However, because of the combination of political, technical, and market factors, the majority of the potential vendors are still too busy trying to ramp up production levels of the 1-Meg part to finish the production engineering of the 4-Meg device. Thus, whatever schedules were promised or projected will probably slip three to four quarters. This would place the availability of the initial volume-production units from early to mid-1989.

The shift could be even further if present market demand continues. This would benefit the industry by allowing more time to recover the investment. However, at least one vendor will take the lead—probably Toshiba. This leaves other vendors to follow as soon as they are able.

Unless a vendor gets back into the market with the 4-Meg design, it will probably be the last chance. With the advanced technology required for the 16-Meg design, it would be very unusual for any company to start cold without the previous experience of the 4-Meg and the 1-Meg.

One key cost factor is the ability to continue using optical steppers at this resolution. Planarized photo resist will be required along with dry etching.

Sampling has already started in Japan. Initially, companies such as Toshiba and Fujitsu had expected to be in production by the third or fourth quarter of 1988. The present market conditions, however, are expected to cause this schedule to shift into 1989.

TI is expected to be the first American company to be in production, probably in early 1989. Micron Technology, the only other U.S. producer, is expected to follow one to two quarters later.

Motorola is not expected to manufacture the parts initially. Under its current agreement with Toshiba, Motorola is expected to conduct both assembly and testing of parts before establishing wafer fabrication (with Toshiba technology).

In Europe, Siemens, which is also using Toshiba technology, claims to be on schedule for the 4-Meg part, which is expected in mid-1989.

The leading player to watch is Toshiba. The company is already sampling, and now has the best chance to be first in production. Whenever Toshiba starts, the rest will follow.

Ferroelectric Memory Could Result in New Products

Ferroelectric, a non-volatile thin-film memory that is process compatible with CMOS technology, has the potential of becoming a significant new product. Assuming no major reliability problems, this approach can be used to produce drop-in replacements for existing static RAMs.

In ferroelectric memory, a sandwich of electrodes and a ferroelectric lead, zirconate, titanate thin-film form a capacitor that will polarize and hold the given charge when the power is removed. Thus, any RAM or programmable memory could retain the pattern when the power is returned.

Currently, the following two companies are sampling devices: Krysalis Corporation of Albuquerque, New Mexico, and Ramtron Corporation of Colorado Springs, Colorado.

It is still too early to determine the long-term viability of this approach, but the potential is significant enough that it should be monitored.

INTERNATIONAL COMPUTRAN CORPORATION **TEC REPORT**

NEC Doubles Speed of 16-bit Microprocessor

Nippon Electric Co. has developed what is reputed to be the world's fastest 16-bit microprocessor, an improved version of its earlier V30 model but featuring an operating speed of 16 megahertz. In addition to its twofold increase in processing speed, the MPU has also breached the 640-KB upper limits in program-handling capacity for 16-bit MPUs.

Observers noted that the new MPU has a capacity approaching that of 32-bit processors, yet has peripheral circuits that allow the use of 16-bit systems, including printers and disk drives. Informed

sources indicated that NEC will begin sample shipments of the "super 16" MPUs within the next few weeks to challenge the U.S. supremacy in high-end microprocessors.

A modified version of the V30 model introduced in 1984, the device features compatibility with Intel's i8086 processor in terms of commands. The V30 has a clock speed of 8 MHz and an address space of 640 KB. Compared with Intel's 80286 and Motorola's 68010, NEC's new processor is said to be 30 percent faster.

Observers noted that, with Intel showing increased reluctance to share its MPU technology with Japanese semiconductor firms, Japanese companies will step up research and development activities to keep abreast and hopefully take the lead from U.S. microprocessor firms.

AEROSPACE

Space Business News

Rolls-Royce Discloses HOTOL Engine Design

HOTOL proponents British Aerospace and Rolls-Royce have been pulling out all the stops in a desperate attempt to retain government funding for the aerospace-plane project.

British Aerospace (BAe) has compiled a consortium of companies to do further work on the plane and to broaden the economic stake of private companies in the project. And engine designer Rolls-Royce has been pulling back the sheath of secrecy shrouding its propulsion concept in hopes that its simplicity will appeal to skeptics, who have argued that the engine is too technologically complex to be workable.

Companies with expertise in materials science, guidance systems, computer software, landing gear, reaction control systems, and other fields are being asked by BAe to pool their resources to work on the project. Specifically, BAe wants the companies to fund half the development costs of an enabling-technology program organized in two phases, each lasting three years.

BAe has asked the U.K. government to match these industrial funds. The teaming underlines BAe's claim that HOTOL development will have far-reaching benefits for a wide range of British industry and widens the base of industrial support for the project.

BAe now believes that a full HOTOL development program could start by 1994 with a first flight in 2000. Initial plans are to build five vehicles, each with a 120-mission lifetime. Only one vehicle would be equipped for manned missions.

Planners continue to insist the program could support 28 launches a year, with each flight having a recurring launch cost of only $5 million. Much of the expense is eliminated through rapid turn-around time, which BAe projects will be on the order of 48 working hours.

Rolls-Royce recently released an elementary diagram of the HOTOL engine's operating principles. Engine architect Alan Bond has described the engine as a brand new cycle, combining elements of air-breathing and rocket operation.

Special Projects vice president Robert Budica of Marquardt in Van Nuys, Calif., after seeing the diagram, disputes the originality of Rolls-Royce's concept. He claims HOTOL's cycle applies a concept his company developed in the 1960s, the "vaporcycle cryojet." The cycle, as Budica explains it, cools incoming air, compresses it using a turbocompressor, then feeds it into a low-pressure rocket chamber where it burns injected hydrogen fuel. The switch from air-breathing to rocket operation consists of a changeover to tanked liquid oxygen, to maintain combustion.

Elements of the cryojet concept received considerable attention at Marquardt during the early 1960s, both in design studies and in experiments. The pertinent material is unclassified. Accordingly, it is possible to describe the HOTOL concept in much greater detail than Rolls-Royce officially has disclosed.

The principal innovation within the cryojet is a large heat exchanger immediately to the rear of the inlet. Its purpose is to remove heat from the incoming airflow, transferring this heat to the hydrogen. This accomplishes several goals. It permits air-breathing operation at speeds up to Mach 5, extending the Mach 3 limit of a conventional turbojet. Removing heat from the incoming airflow permits air-breathing operation at

higher speeds.

It also increases the density of this airflow, permitting use of a more compact turbocompressor. In addition, it adds heat to the hydrogen, increasing its energy content. The aerodynamic heat boosts the performance of the hydrogen fuel, rather than letting it be wasted. Lastly, the heated hydrogen then is available to run a turbine in an expander cycle like that of some rocket engines.

The heat exchanger counterflows the hydrogen from back to front. This hydrogen comes in as a tanked liquid, at the rear of the heat exchanger where the airflow is coolest. The hydrogen flows forward through thin-walled passages, warming as it proceeds, while removing heat from the airflow.

Downstream of the heat exchanger, the resulting chilled and dense airflow passes into a turbocompressor like that of a jet engine. Driving this compressor is a turbine, which runs off the expansion of the vaporized hydrogen gas that exits from the heat exchanger. Additional hot hydrogen, produced through regenerative cooling of the rocket nozzle, also may be available to drive this turbine.

The compressor boosts the air pressure to above 200 pounds per square inch. Exiting the compressor, the air flows into the rocket combustion chamber. There it burns the flow of hydrogen that comes partly from the tanked liquid and partly from the turbine exhaust. The rocket produces thrust throughout the entire flight, both in the air-breathing mode and in the pure-rocket mode. The switch occurs at Mach 5 and 85,000 feet.

As the aircraft gains speed, the inlet temperature increases, as does that of the hydrogen exiting from the heat exchanger. This increases the power from the drive turbine, permitting greater compression of the airflow. This compensates for the fall-off in ambient air density with increasing altitude.

The performance of the cryojet is limited by the increasing amounts of liquid hydrogen needed to cool the airflow as the Mach number and its attendant aerodynamic heating increases.

Marquardt studies show that the cryojet can achieve a specific impulse exceeding 4,000 seconds while at rest, dropping to well over 3,000 seconds at Mach 4. This contrasts to under 500 seconds for even the best pure-rocket system employing hydrogen and oxygen.

That's why the HOTOL has widely been regarded as promising.

SPACE COMMERCE BULLETIN

Panel Approves New Shuttle Pricing Policy

The price NASA is likely to charge its space-shuttle customers for an entire cargo bay is closer to $110 million than to the $245 million proposed by a White House working group, government officials said. They refused to divulge specifics, saying only that the new price would be revealed in request-for-proposals (RFPs) for an administration-supported, commercially developed space facility (CDSF), a man-tended free-flyer that the government may lease for five years at a cost of up to $700 million.

The issue, described by one administration official as "a tempest in a teapot," created a firestorm at a recent House Space Subcommittee hearing when lawmakers questioned NASA, Transportation Dept., and Commerce Dept. officials on the reasons for boosting prices from the current base of $74 million (in 1982 dollars—that translates to $110 million in current-year money) to $245 million, which reflects the actual cost of flying the shuttle. It also became a topic at a separate Senate hearing.

"For the life of me, I can't figure out what idiot decided that was a rational policy," said Rep. Walker (R-Pa.), complaining that higher prices have a chilling effect on commercial endeavors, including proposed CDSF and Spacehab shuttle modules, which eventually must pay for shuttle rides. He also complained that shuttle pricing wasn't within the purview of the administration. Congress set shuttle prices in the FY 1986 shuttle-authorization bill, he said. "We're not going to stand for this kind of nonsense," Chmn. Nelson (D-Fla.) told witnesses. "You can take that back to your superiors."

They apparently did. Members of White House Senior Interagency Group-Space (Sig-Space) later were polled on the new shuttle pricing policy, and the Office of Management & Budget (OMB), which originally approved a much higher price, sided with NASA in a meeting with top space-agency officials, agreeing that the price should be kept at $110 million, officials said. The new price is based on additive costs and was changed to reflect 1988 expenses. Even so, the new price will affect some satellite

payloads. Although the administration has eliminated most commercial satellites from the shuttle manifest, NASA still is obligated to launch satellite payloads belonging to foreign governments.

The higher number that dominated discussions in both House and Senate hearings was "leaked" to Capitol Hill after a Sig-Space working group conducted a "straw vote" a few days earlier on the appropriate cargo-bay price. The decision was critical because the administration needed a shuttle pricing policy before it felt comfortable releasing an RFP on a CDSF project. Despite apparent resolution of the pricing issue, other problems remain and an RFP isn't expected out until after Congress returns from Easter recess—if even then.

At the hearings, administration officials wouldn't discuss details, but they also didn't dispute claims that the White House group had voted 7-1 to increase prices to $245 million—nearly three times the current maximum level. NASA deputy administrator Dale Myers testified that the amount reflected all personnel costs, overhead, contingencies, depreciation, and network support. He called the figure "an upper limit" that was based on a low flight rate, and said it could drop once the flight rate increased.

The group reportedly adopted the higher limit because "this is a case where doctrine weighed over substance." Following Reagan administration doctrine, the group opposed any appearance of subsidization, sources said, and eliminated that possibility by charging the full price. It wasn't clear who voted in favor of the proposal, although NASA indicated it had opposed it. Courtney Stadd, director of the Transportation Department's Office of Commercial Space Transportation, apparently didn't support it, either. "I hear you. It's nuts," he said, agreeing it would significantly undermine the administration's effort to commercialize space. "I've been equally frustrated over internal debates." Other members of the group included the Defense and State Departments, the CIA, and the National Security Council.

TELECOMMUNICATIONS

FIBER OPTICS WEEKLY UPDATE

NEC Develops Optoelectronic Chip for LANs

NEC Corp.'s Optoelectronics Research Laboratory has developed optoelectronic integrated circuits (ICs) that could replace the hybrid circuits now in use, easing the implementation of optical local-area networks (LANs).

NEC researchers have demonstrated that their long-wavelength devices can communicate reliably up to 52.5 kilometers at 1.2 gigabits per second. The new devices consist of a transmitter chip with an indium phosphide (InP) laser and metal-semiconductor field-effect transistor drivers and a receiver chip based on an InP photodiode. They should be easy to use in LANs because they are small and require no assembly.

In the process of development, NEC engineers solved a materials problem that has plagued designers of optoelectronic ICs for LANs. All the circuit-device experience in compound semiconductors has been with gallium arsenide (GaAs), but InP is needed to make optical devices that operate in the 1,300- and 1,550-nanometer long-wavelength bands, which are favored for long, repeaterless spans. They circumvented this by using molecular-beam epitaxial growth to fabricate a heterostructure with single-crystal GaAs on a semi-insulating InP substrate. The process enables operation at signal rates of up to 2.4 Gbps.

A representative for NEC said he expects the demand for devices in LANs and subscriber circuits will eventually supersede that for backbone telephone company lines.

INTERACTIVITY REPORT™

Videotex, ISDN Network Planned for Florida Community

Videotex terminals and related interactive facilities will be included in the price of every home in Heathrow, a new town near Orlando, Florida. The equipment, to be installed starting in September, is part of a fiber-optics setup that expects to deliver interactive monitoring and video-on-demand services

throughout the 4,400-home development.

The venture, which is also a commercial rollout of ISDN technology, is being coordinated by Southern Bell, Northern Telecommunications, and Heathrow Telecommunications, a subsidiary of project organizer Heathrow Land and Development. Bell South's primary focus seems to be on development of the broadband fiber-optics system that could eliminate the need to string coaxial TV cables into each home; Northern Telecom is providing the DMS 100 central-office switch as well as the optical network interface in each Heathrow home and office.

No manufacturer has been selected to build the home terminal, although sources say Northern Telecom and Digital Equipment Corp. are both contenders. The "integrated" terminals must utilize full ISDN bandwidths; the developer does not want simply a "generic PC." The price of the home terminal or the cost of services has not yet been determined, although these expenses will be relatively low in comparison to prices in upscale Heathrow.

Southern Bell says the Heathrow network is the first commercial application of ISDN capability to residences, the first delivery of ISDN over optical fiber, and the first use of single-mode fiber to deliver digital voice, data, and video services to homes via the same transmission line.

The Heathrow network will eventually provide voice and data services, computer-access capability, security monitoring, meter reading, home-energy management, cable-television signals, and traditional telephone services through a single line. Developers hope homes will have access to telebanking and locally originated information services as well as national services through gateways. For more information, contact Heathrow Telecommunications, 250 International Parkway, Heathrow, FL 32746. Telephone (305) 333-1000.

TELEVISION DIGEST

VHS-Recorder Makers Agree to Anti-Copy Measure

Almost all manufacturers of VHS video recorders have agreed to specifications that will make it impossible to copy most prerecorded tapes, *Television Digest* has learned. New specs will keep recorders from duplicating tapes recorded using the Macrovision process, which is now included on most feature-film cassettes. It's estimated that Macrovision has been effective in blocking copying by about 75 percent of VCRs in the past.

With no publicity, a private half-page memo sent to all VHS licensees in April 1987 by JVC recommended changes in the circuitry of VCRs to eliminate the possibility that copies could be made of prerecorded cassettes treated with the Macrovision anti-copy process.

In answer to our question, JVC said in Japan that it "has not changed the design specifications" for VHS video-cassette recorder circuitry "related to the Macrovision pulse." However, we've learned that JVC—while not altering compulsory license specifications—did recommend two optional changes in the response of luminance-signal automatic gain control (AGC), without specifying actual circuitry. The company is leaving circuitry specification to individual manufacturers.

Although the circular, designated "ref VHS 23," was only a recommendation—not a requirement—its obvious purpose was to prevent recorders from making copies of Macrovision-encoded material. One industry source said all of the world's VCR manufacturers except one now have agreed to abide by the terms of JVC's recommendation. Manufacturers obviously prefer a unilateral system such as Macrovision to a bilateral system that would require installing a chip or circuit. Adoption by manufacturers presumably was done with an eye to good relations with the film industry, and to head off any legislation or other requirement mandating a bilateral "chip" system.

The JVC memo defines recommended AGC response to peak white video level and to sync pulse level. Macrovision works by altering sync on recording to levels that appear to be nonstandard to recorders. Some recorders—including at least one made by JVC—have been able to cope with these nonstandard levels and thus defeat Macrovision. The new recommendation is designed to ensure that AGC response will be thrown by Macrovision and recorders will refuse to copy.

In effect, JVC's recommendation restores AGC circuitry to a system used in the early 1980s,

according to one observer. After Macrovision was widely adopted on recorded movie tapes, one engineer said, VCR manufacturers started to make adjustments in the ACG system that, in effect, let their recorders copy Macrovision-encoded tapes. Macrovision president Eugene Eidenberg said, "After [Macrovision] got into the marketplace, we began to see changes which made some recorders less responsive."

A Motion Picture Association of America (MPAA) official indicated he was familiar with the memo, but declined to comment further. JVC's memo already had been issued when President Jack Valenti last August said that the MPAA had abandoned efforts to push for a VCR anti-copy chip in favor of Macrovision. He also said the MPAA hoped for a "voluntary change in VCR circuitry" by hardware companies to inhibit copying.

MANUFACTURING AUTOMATION

Flexible Automation

Object-Oriented Programming Arrives

Programs written in object-oriented languages are beginning to show up in manufacturing. If the benefits experienced by early users are fully realized, you may begin to see complex software products come to market at a much faster pace. And they may be easier to tailor to individual needs.

Among products now heading for the marketplace are a factory data-collection system, Matrol, which will be released soon by the McDonnell Douglas Information Systems Group. 5th Gen will soon release a product to help schedule factories. And many CAD companies are using object-oriented procedures to capture the interrelationship between parts of a product.

One of the most fully developed products for developing and testing factory-control systems has been developed by Savoir. Savoir bases its simulation techniques on Grafcet, a powerful technique for designing systems with complex parallel and sequential paths. Savoir has enhanced Grafcet to give it object-oriented qualities, principally through the addition of messaging.

A handful of terms describe the basic ideas embodied in object-oriented programming—among them objects, messaging, class, and inheritance. An object is a sort of black box that encapsulates data to be manipulated and procedures to manipulate the data. These packaged objects can receive a message to do something but cannot be told how to do it.

Objects are collected together into classes that have relationships with one another. Objects in a class have the same data elements and use the same procedures to manipulate the data.

Inheritance is a key concept. Objects inherit characteristics from predecessors or classes. One class could describe a bar-code reader; another class, a bar-code reader with keyboard. The second device inherits data and procedures from the bar-code reader.

Inheritance reduces the amount of new code required for large systems because a new class can use procedures from an earlier class. Because of black-box characteristics of objects, a change at one part of the system doesn't have ripple effects on other parts.

ARTIFICIAL INTELLIGENCE

AI TRENDS

How to be Properly Informed in the Information Age

Information overload.

We all know the term: an over-abundance of data that's impossible to keep up with.

We all know the cause: too many reports, too many journals, too many memos, too many magazines, too many newspapers, and too little time.

We all know the symptoms: huge IN baskets that don't seem to shift to the OUT baskets; three back issues of *Forbes* and two days of the *Wall Street Journal* that haven't even been glanced at; unread reports that need to be reviewed for tomorrow's meeting that have been sitting patiently on your desk for the past week.

We all know the disease: the feeling that you're getting left behind and that, quite simply, you will never be able to catch up.

Unfortunately, not one of us knows the cure.

Sure, you can take it home and read it over the weekend (hah!), or you can read it on the way home (good only if you're on the train or someone else is driving the car), or you can read it on your next plane trip (better, but that gets expensive), or you can set aside a certain time each day to read (somehow, other people don't think you're really working when you're reading and feel it's a great time to chat). In all, there's really no decent solution.

Unless...

There appears to be an interest in intelligent text retrieval and management that is currently growing at a rate fast enough to make your head spin, if not snap. If you thought that expert-system and neural-network interest set the buzzwords in motion, wait until you see what intelligent text has in store.

Basically, the problem of information overload is that we get all this information in bulk form: that's the way we input it, it's the way we store it, it's the way we retrieve it. For too long our concerns have been with better ways of inputting information into databases, with everything from scanners to digitizers to mice and joysticks. And then we've spent time giving that information more room to get lost in: starting with 10-megabyte hard disks (which are already too small) on up to CD-ROM and laser disks (which can store your local library on a small formatted section of disk). So we're getting all of this information into bigger information-storage spaces.

But for the life of us, we can't get it back out in the form that is most useful to us. It's like wanting to check on the type of oil that your Chevy Dereeta needs and getting handed the collected volumes of repair manuals for all American-made cars since 1932.

Going page by page through the *Journal*, or sifting through 20-page reports until you find the paragraph that is pertinent to your needs, boils down to one thing—wasted time. If you could get the information you want *presifted* so that all the unwanted data clutter and noise weren't obstacles, then information overload could be reduced. Remember 8-track tape cartridges? One of the reasons for their failure was the inability of the listener to rewind the tape to a specific song selection. That meant that one had to listen to a whole track of music before getting to the desired piece. This was inefficiency at its height—the music was in there somewhere, you just had to put up with the clutter around it.

CDs have eliminated this inefficiency by making recorded music programmable. Not only can you immediately go to the selection you want, but you can listen to that one piece (or even a piece of the piece) as many times as you want—without interruption. This means that you can listen to the cannon fire from the *1812 Overture* 20 times in a row without moving from your chair. You might drive your neighbors insane in the process, but that's the price of technology.

Intelligent text hopes to provide the same kind of control over textual information that we can exert over other types of media. By using a combination of artificial-intelligence and text-management technologies, the ability to presort and sift your information—in effect, tailoring it to your needs—may become a reality. Not tomorrow, but hopefully not too far down the line.

The premises are quite simple. If an "intelligent" system "knows" what the user is looking for, it can more accurately deliver the required information. Much as a clerk or librarian is better able to retrieve books or documents when provided with more concise parameters, an "expert librarian" within a computer system could help sort out your data needs with a good degree of precision. Think of it this way: when you want a book from the library, you're more apt to get it if you know the author's name and the title of the book. If you just know that it's a fiction work, you may have to wade through more texts than you know what to do with.

Intelligent retrieval provides for more precision because the user defines what his or her needs are before a search is undertaken. Given the proper parameters, the system can then scan documents to determine exact fits within those parameters (with a little leeway of course—it's still only a machine). In this way, you get your information on computer news and sports, but not on mass murders and the price of pork-belly futures.

There's obviously a lot more to this area than I have briefly touched on here. There are also related areas that bear some examination, specifically on-line information systems and hypertext. I'll be spending more time discussing all of these in the near future, because to my mind they represent some of the most practical areas to which AI can be applied.

If I don't die from information overload first.

AI is Key to PRC Intelligence Processor

A Virginia-based company is letting machines do the thinking when it comes to keeping the enemy off balance on the battlefield.

Planning Research Corp. (PRC) is testing an artificially intelligent device that interprets enemy messages. The device then uses these messages to predict where a foe might attack next. Two computer systems work together in PRC's automated message-handling system (AMHS), which is called PAKTUS for PRC Adaptive Knowledge-based Text Understanding System.

PAKTUS uses natural-language understanding technology to decipher free-text messages, such as intercepted enemy signals. The system includes five knowledge-base elements, which are created from the wisdom of human experts.

The five knowledge bases include a lexicon or list of terms, a grammar element, two templates that format data so it can be used by an expert system, and a user profile. If the system does not understand a word, it either guesses at a meaning or asks its human operator for help.

PAKTUS includes a discourse-analysis module that searches conceptual structures built by the system to match messages with possible enemy plans.

Once PAKTUS has broken down and interpreted an intercepted message, it feeds the data to a Moving Target Analyst (MTA) expert system on a linked machine. The MTA works with PAKTUS to predict future enemy movements. Enemy intentions can then be displayed on a map shown on a computer screen.

The PAKTUS and MTA systems can be linked by a local-area network. Interpreting a short message takes about three seconds.

A PRC spokesman said the system could be formatted to ignore bogus messages transmitted by the enemy to confuse traffic analysis and code-breaking. Once formatted, the system flags possible decoy messages for analysis by the human operator.

The system must be programmed with the special grammar and lexicons needed for different applications. For example, when used to predict the movements of infantry units, it must draw on the expertise of analysts skilled in interpreting enemy tactical-operations messages.

The system also can be linked to an automatic database-update program instead of an expert system. PAKTUS can be run on a 3.5-megabyte Xerox 1186 computer, an Apple Macintosh, or a Sun workstation. The system costs about $200,000, according to PRC, depending on options and support services supplied with the basic product.

PRC has sold the system to the Air Force's Rome Air Development Center as well as to other intelligence agencies of the U.S. government. The company hopes to sell the system to the U.S. Navy bomber groups, so tactical air commanders can use their forces in the most vital spots.

The new centers will have secure communications and automatic battle-management equipment such as map displays on consoles that highlight Army units and friendly aircraft.

Army Funds Neural-Net Research

The Army wants help from one of the most advanced types of computer technologies in solving its battlefield computer problems.

Neural nets, a type of computer in which the hardware adjusts to create software by giving different functions to brain-like hardware "cells," are being funded by the Army's Laboratory Command, Electronics and Devices Laboratory.

The Army lab has chosen Hecht-Nielsen Neurocomputers of San Diego, Calif. (HNC), an early leader in the emerging field, to "identify Army battlefield problems and develop a design for a battlefield neurocomputer to satisfy the processing requirements." Initial funding by the lab is at a level of $50,000 for six months of research, HNC said.

"This award marks an important first step in the application of neural-network technology to defense systems," said Robert North, president and chief executive officer of HNC. "It indicates both the Army's interest in pursuing this powerful new technology, and their recognition of HNC's leadership in the neurocomputing field."

HNC said it expects neural nets to be used in three

key military areas: knowledge processing, sensor processing, and control.

For knowledge processing, neural nets shine because they can tolerate contradictory and imprecise data, and process large amounts of that information quickly, HNC said. The systems could be used to predict enemy behavior based on observation of training exercises, and to interpret photographs of enemy formations.

Neural nets could also reduce the need for very complex algorithms for performing sensor processing, according to HNC. The systems develop their own rules for solving problems based on experience. They thus provide problem-solving ability similar to that of humans.

In control technology, neural nets could be used to make robots that can learn to perform tasks by "watching" humans perform them, or by feedback from a trial-and-error approach.

Robots controlled by neural nets could learn to compensate automatically for such factors as operator fatigue, battle damage, and environmental changes, HNC claimed.

Other potential military applications of neural nets include:

- radar, sonar and image processing, including noise reduction, feature extraction, and object recognition;
- data fusion and data compression; and
- weapons aiming and steering.

MATERIALS SCIENCE

militarySPACE

NASP Combines Materials Efforts

Using funds already in the budget, the National Aerospace Plane (NASP) program plans to spend $200 million to develop and begin production of advanced materials for the X-30 hypersonic research vehicle.

The emphasis will be on treating materials development as an integrated part of the entire NASP effort, and on bringing together materials expertise in U.S. aerospace companies and research laboratories. All five of the principal NASP contractor teams—Rockwell International, McDonnell Douglas, General Dynamics, Pratt & Whitney, and Rockwell's Rocketdyne division—will participate and share their technologies.

"Since the airframers are working intimately with the engine contractors, we will be able to focus on actual designs, as opposed to doing a 'great sandbox' technology-base program," said Robert Williams, outgoing NASP program manager. The program will address the concerns of a Defense Science Board task force, which said NASP designers were counting on materials which don't yet exist.

The three vehicle contractors—Rockwell, McDonnell Douglas, and General Dynamics—are each working on materials for NASP airframes. Rockwell's program is focused on monolithic titanium-aluminides, which are alloys formed with rapid solidification powder metallurgy.

McDonnell Douglas is examining titanium-aluminide metal-matrix composites, which combine the alloys with nonmetal materials. General Dynamics' effort stresses nonmetal refractories, including carbon-carbon composites.

The two NASP engine designers are focusing on materials of greatest interest for the X-30's supersonic combustion ramjet engines. Pratt and its teammate Marquardt are examining highly creep-resistant metals. Rocketdyne is exploring high thermal-conductivity metalloids, which use matrices of copper and graphite. Each development effort will include detailed characterization of material chemistry and characterize materials properties such as creep (buckling) or high-temperature deformation. "We don't want a creepy airplane," Williams said. "That would give us the creeps."

The materials program will also examine coatings that provide high thermal emissivity, oxidation resistance, low catalycity (promotion of heat-producing chemical reactions in adjacent air), resistance to hydrogen embrittlement, and low absorption of contaminants.

Processing requirements will also influence materials research. After selecting candidate materials, contractors will fabricate and test sub-scale X-30 components. The tooling used for sub-scale production will then be scaled up to create pilot lines for full-scale structural and engine components. Pilot production of test components will begin by 1991.

Advanced structural materials will be used to

construct X-30 fuselage segments, cryogenic tankage, wing leading edges and hot wing-to-cold body carry-through structures. Engine makers will use the materials to build flight-weight engine prototypes for test in Mach 8 wind tunnels.

The materials effort is being managed by Terry Ronald at the NASP joint program office at Wright-Patterson Air Force Base in Ohio. Each contractor will serve as a materials subcontractor to the other four NASP teams.

The pooling of industry experience and know-how will be critical, Williams said. "We've had a lot of interchange between people from different companies. People are saying, 'Hey, we tried doing diffusion bonding this way and it didn't work; you ought to try it that way.'"

Specialist facilities within individual companies, as well as specialist technical groups, will be shared on a program-wide basis. "Rockwell has a 20-ton press for fabricating large structural pieces; it exists nowhere else in the country," Williams said. "McDonnell Douglas is a leader in composite development. Rockwell will be subcontracting to McDonnell, and McDonnell will have people working under contract to Rockwell."

The materials effort emphasizes what Williams calls the "synergistic advancement" of technology. "We will couple design-driven activities with the fundamental work in materials science," he says. "The airframe designer gives his requirements to the materials guys and they iterate back and forth. The airframer might say, 'I need more ductility.' The materials specialist replies, 'I can give you more ductility, but you'll have to accept less ultimate strength. Is that OK?' The airframe man then says, 'Hey, that's OK. I need low-temperature strength and ductility, but at high temperatures I don't worry so much about strength as long as I have stiffness.' So there's a detailed give and take.

"This iteration, in designing materials, is not understood," Williams emphasizes. "There's a world of materials scientists, and it's completely segregated from the world of materials users."

The integration can only be done through the type of organizational structure established by NASP, he said. "Otherwise, you don't get the communication. Everyone breaks into their own little fields of knowledge, and it just doesn't work."

Fax Machines, Film Scanners

OFFICE PRODUCTS

FAX-L3100 fax machine. Sends a document in three seconds; can transmit in sequence to 120 locations. The device works with Group 4, Class 1 terminals and offers one-touch and speed dialing. Resolution is 400×400 dots/inch with 16 shades of gray. Uses plain paper. $8,495. Canon U.S.A. Inc., 1 Canon Plaza, Lake Success, NY 11042. (516) 488-6700. *Circle 1.*

Bravo slide maker. Looks like a conventional desktop office copier, but produces color slides, prints, and overhead transparencies from flat documents such as computer printouts, illustrations, brochures, and photographs. $2,595. Polaroid, 575 Technology Square, Cambridge, MA 02139. (617) 577-3796. *Circle 2.*

FaxPhone 25 fax machine. Includes telephone and copier functions, and has an RS-232C interface to act as a personal-computer scanner or printer. The machine provides a 10-page automatic document feeder and delayed transmission. Reads halftone images in 16 shades of gray. $2,695. Canon U.S.A. Inc., 1 Canon Plaza, Lake Success, NY 11042. (516) 488-6700. *Circle 3.*

Meridian Norstar phone system. Made for businesses with as many as 100 telephones that have liquid-crystal displays to show prompts and other information. The system connects to modems, fax machines, answering machines, credit-card readers, and dial-by-name directories. It also monitors and records calls through a personal-computer interface. $400 per station. Northern Telecom, Meridian Key Division, 565 Marriott Dr., Nashville, TN 37201. (615) 885-3510. *Circle 4.*

Open-Net network software. Links personal computers in a contention-ring network, which combines the best of token-ring and Ethernet systems, according to the company. The software allows simultaneous access to shared printers, and supports disks and CD-ROM devices with nonstandard sector sizes. It supports 10 computers per network cluster and accommodates laptops, the IBM PC/XT/AT, the PS/2, and 80386-based computers. $299 per computer. Applied Knowledge Groups Inc., 33 Music Square West, Suite 102-B, Nashville, TN 37203. (615) 244-2828. *Circle 5.*

RSVP 6000 voice-mail system. Answers the telephone and processes voice messages for as many as 100 people. The system works with touch-tone phones. $8,000 to $10,000. The RSVP 3000 for 24 users is $4,500. AT&E Systems Inc., 1400 N.W. Compton Dr., Suite 300, Beaverton, OR 97006. (503) 690-2000. *Circle 6.*

System 10000 computers. These multiuser computers are based on a 32-bit processor and offer 2 to 32 megabytes of memory. Five models connect 16 to 1,000 terminals and let users participate in a variety of local and wide-area networks. A computer-aided software-engineering program speeds applications development and maintenance; all models support SNA and OSI standards. $31,210 to $226,900. NCR Corp., 1700 S. Patterson Blvd., Dayton, OH 45479. (513) 445-2075. *Circle 7.*

COMPUTER HARDWARE

1435 slide scanner. Converts 35-millimeter mounted and unmounted slides, negatives, and film strips into computer images. The device captures a color image in less than three minutes with a resolution of 2,800 dots/inch; its dynamic range is 12 bits/pixel for each color. $9,900. Eikonix Corp., 23 Crosby Dr., Bedford, MA 01730. (617) 275-5070. *Circle 8.*

Apple Crate SCSI drive. Gives Macintosh Plus, SE, and II computers a 20-, 40-, or 60-megabyte external hard-disk drive. An additional port links as many as seven SCSI devices. Software includes utilities for formatting, initializing, testing, and verifying the disk. $560 for a 20-megabyte system, $770 for 40 megabytes, and $839 for 60 megabytes. Apple Crate Inc., 6850 Vineland Ave., North Hollywood, CA 91605. (818) 766-4001. *Circle 9.*

ATVista graphics card. This one-megabyte card equips the IBM PC/AT and compatible computers to display and capture video images. The card has a 32-bit graphics processor and a palette of 16.7 million colors. $2,995. Truevision Inc., 7351 Shadeland Station, Suite 100, Indianapolis, IN 46256. (317) 841-0332. *Circle 10.*

ColorScript 100 thermal printer. Produces about one page of text and graphics per minute with 300×300-dot/inch resolution using a three-color ink film. The printer's external controller uses a 68020 processor and has eight megabytes of random-access memory and one megabyte of read-only memory. Also offers a 20-megabyte hard disk and RS-232C, parallel, and RS-422/Appletalk ports. $24,995. QMS Inc., 1 Magnum Pass, Mobile, AL 36618. (205) 633-4300. *Circle 11.*

Image Scanner graphics card. Turns any Epson dot-matrix printer into a scanner with selectable resolutions as fine as 300 dots/inch horizontally and 216 dots/inch vertically. Requires an IBM-compatible personal computer with 512 kilobytes of memory and a graphics adapter card. Includes software and a scanning head with a six-foot cable. $195. Computer Aided Technology Inc., 7411 Hines Place, Suite 212, Dallas, TX 75235. (214) 631-6688. *Circle 12.*

P19CU00 color monitor. A 64-kilohertz, 19-inch monitor with a resolution of 1,280 pixels×1,024 lines and a 0.31-millimeter dot pitch. Includes a tilt-and-swivel base and external controls. $3,495. Toshiba America Inc., Electron Tubes & Devices Division, 1101-A Lake Cook Rd., Deerfield, IL 60015. (312) 945-1500. *Circle 13.*

Quadboard PS/Q memory board. Includes a bidirectional parallel port and an RS-232C serial port. The board provides as much as four megabytes of memory for the IBM PS/2 Models 50 and 60. It works with LIM 4.0 expanded memory and OS/2 extended memory, and also with programs using 80286 CPU protected mode. $595. Quadram, 4355 International Blvd., Norcross, GA

30093. (404) 923-6666. *Circle 14.*

RV20 optical drive. This external drive offers two gigabytes of write-once, read-many (WORM) optical memory for DEC VAX and MicroVAX computers. The system stores the data on a removable cartridge. The average sector-access time is 150 to 250 milliseconds. From $30,000. Digital Equipment Corp., 146 Main St., Maynard, MA 01754. (617) 897-5111. *Circle 15.*

Scanmaster/35 film scanner. Captures images from 35-millimeter film for use with IBM PC-compatible computers and Macintosh II computers. Scanning resolution is 2,000×2,000 dots/inch, and images can be rotated 180 degrees. Scans positive, negative, color, black-and-white, roll, and mounted film. Comes with software that lets users manipulate images and adjust color and contrast. $8,195 with software, $6,995 without. Howtek Inc., 21 Park Ave., Hudson, NH 03051. (603) 882-5200. *Circle 16.*

Sun386i/150 workstation. Built around an 80386 processor running at 20 megahertz, this station has four megabytes of memory and performs more than three million instructions/second. The operating system is compatible with Unix and MS-DOS. Includes a 14-inch color monitor, a 91-megabyte hard disk, a 3½-inch disk drive, and four IBM-compatible expansion slots. $10,990. Sun Microsystems Inc., 2550 Garcia Ave., Mountain View, CA 94043. (800) 821-4643; in Calif., (800) 821-4642. *Circle 17.*

■ COMPUTER SOFTWARE

Enigma data protector. Allows confidential transfer of data from a personal computer to a mainframe through a local-area network, a public network, or direct terminal connection. The software encrypts data in accordance with National Bureau of Standards and ANSI standards, but protects information by not sending encryption keys with the data. Includes report-writing and maintenance programs, plus help screens. From $50,000. Cappcomm Software Inc., 26 Journal Square, Suite 1003, Jersey City, NJ 07306. (201) 795-1500. *Circle 18.*

IDMS/SLQ database manager. A package for DEC's VAX computers that helps manage relational databases. It supports continuous, unattended operations and guards against failure and data corruption if a system component fails—on-line recovery occurs automatically. Running on a VAX 8550 under VMS 4.6, the software handles 13.4 transactions/second with a database of one million account records, according to the company. $6,000 to $280,000. Cullinet Software Inc., 400 Blue Hill Dr., Westwood, MA 02090. (617) 329-7700. *Circle 19.*

Maximizer sales manager. Organizes information on clients, offers sample letters and automatic printing, helps analyze payments and price lists, and tags potential clients. The package runs on IBM-compatible computers using DOS 3.0 or later versions. $495; a local-area network version costs $495 for each additional three users. Pinetree Software, 8100 Granville Ave., Richmond, British Columbia, Canada V6Y 1P3. (800) 663-0375 or (604) 270-3311. *Circle 20.*

Opus I drawing program. Helps create technical diagrams, maps, floor plans, flowcharts, and schedules; stores as many as 10,000 records with any drawing. Users access the records by pointing to part of the picture with the computer's cursor. Provides a variety of colors, patterns, line widths, and typefaces. Shares images with PageMaker, Windows Paint, and Micrografx Windows Draw software. $395. Roycore Software Inc., 749 Brunswick St., San Francisco, CA 94112. (415) 333-7833. *Circle 21.*

PicturePak image libraries. Three collections of business-related images, entitled Executive & Management, Sales & Marketing, and Finance & Administration. All work with WordPerfect 5.0 word-processing software. $99.95 each; $250 for all three. Marketing Graphics Inc., 401 E. Main St., Richmond, VA 2329. (804) 788-8844. *Circle 22.*

Printer Genius utility. Provides access to printer functions, including variable typefaces, justification, line spacing, and type styles. A one-line word processor lets users edit and print small amounts of text, such as an envelope address, without leaving the program they're in. Works with most popular printers; runs under DOS 2.0 or later versions. $69. Nor Software Inc., 527 Third Ave., Suite 150, New York, NY 10016. (212) 213-9118. *Circle 23.*

Vaccinate anti-virus programs. Two programs that guard files from computer "viruses"—programs that invade other programs and multiply, potentially destroying data. The Syringe "vaccine" program enters programs and warns users if it detects other, nastier interlopers. The Canary program alerts users of viruses contained in files received from bulletin boards or other public sources. Both programs are part of the Protec security system, which runs on IBM-compatible computers. $195. Sophco Inc., Box 7430, Boulder, CO 80306. (800) 922-3001; in Colo., (303) 444-1542. *Circle 24.*

Wisard Forecaster decision aid. This add-in program for Lotus 1-2-3 helps predict trends. The program determines seasonal patterns and checks for "white noise," collecting data from spreadsheet columns, rows, blocks, or a combination. Supports a math coprocessor; runs on IBM-compatible computers with 640 kilobytes of memory. $149. Wisard Software Co., Box 19730, Green Bay, WI 54307. (414) 436-2341. *Circle 25.*

■ COMMERCIAL/INDUSTRIAL

Small Footprint videoscope. Performs three-dimensional video inspection of machine, ceramic, etched, and electronic parts as large as 8×8×6 inches. The scope includes a stage, optics, camera, computer, digital image processor, video monitor, printer, and keyboard, yet takes up only 12 square feet of floor space. Automatically aligns and levels parts; includes software. $90,000. Matrix Videometrix, 5321 Sterling Center Dr., Westlake Village, CA 91361. (818) 707-0423. *Circle 26.*

5870 waveform monitor/vectorscope. Digitally displays SCH phase on screen. The waveform monitor shows A and B inputs to match amplitude and timing and includes chroma, IRE, and flat filters. The vectorscope section provides overlay display of A and B inputs, R-Y mode, internal Z-axis blanking, and continuous phase adjustment. $4,995. Leader Instruments Corp., 380 Oser Ave., Hauppauge, NY 11788. (800) 645-5104; in N.Y., (516) 231-6900. *Circle 27.*

BT-1 bit-error-rate tester. This hand-held unit performs bit-error-rate, polling, and timing tests, showing results on a liquid-crystal display. Offers synchronous or asynchronous testing using a "quick brown fox" message or the 63, 511 or 2047 pseudo-random bit patterns. Performs polling tests on as many as 16 remote locations. $795. DCB, 807 Pioneer, Champaign, IL 61820. (800) 637-1127; in Ill., (217) 352-3207. *Circle 28.*

CCS Symbol Library images. A collection of symbols representing furniture, appliances, and fixtures for laying out floor plans, designing home interiors, and landscaping. A second collection provides symbols for composing flow charts. $39.95 each. CCS, 189 Airport Blvd., Burlingame, CA 94010. (415) 692-7250. *Circle 29.*

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d Corp., rch associate

managing director

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e Electric, president, er

Colgary, dir., ore Research Group Calgary, mgr., ology Tronsfer Group

, president, founder

Connector Systems, gineer

York, PA 17404
(717) 845-8704

Roy Lehman, dir. quality assurance

Du Pont Connector Systems, quality engineer

Teledyne MIL 1300 Terra Bella Ave. Mountain View, CA 94039 (415) 968-9241	To provide radiation-tolerant CMOS logic products for the military, aerospace, avionics, and satellite-telecommunications industries.	$3.5 billion from parent company, Teledyne Semiconductor	Mitch Gooze, president, co-founder Lee Arnold, dir. marketing & sales, co-founder	Teledyne Semiconductor, president (current) Teledyne Semiconductor, consultant
Unidyne Training Facilities 5900 Olson Memorial Hwy. Minneapolis, MN 55422 (612) 544-2721	To supply facilities to train athletes; the company is building a swimming treadmill at the U.S. Olympic Training Center in Colorado Springs, Colorado.	Wholly owned subsidiary of FluiDyne Corp.	James T. Dunn, president	FluiDyne, v.p. business development (current)

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■ COMPUTER

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MARKETWATCH

NEW COMPANIES

COMPANY	BUSINESS OBJECTIVE	FINANCING	OFFICERS	OFFICERS' PREVIOUS POSTS
Advanced Ceramic Technologies 72 Veronica Ave. Somerset, NJ 08873 (201) 214-1050	To commercialize a new material that strengthens ceramics for industrial, electronic, and aeronautical applications.	$640,000 in first round from Gryphon Ventures	H. Christopher McGowan, president	Englehard Corp., research associate
Atom Tech 1829B De Havilland Dr. Newbury Park, CA 91320 (805) 499-0091	To market its parent company's thin-film technology components and systems for the medical industry.	Wholly owned subsidiary of Ion Tech Ltd.	Ion Ferguson, president	Ion Tech, managing director
Dell Corporate Services 9505 Arboretum Blvd. Austin, TX 78759 (512) 338-4400	To manufacture and market equipment for five Dell Computer subsidiaries.	Wholly owned subsidiary of Dell Computer	Michael S. Dell, CEO E. Lee Walker, president	Dell Computer Corp., CEO, chairman (current) Dell Computer Corp., president (current)
Digital Video Systems 809 Wellington St. N. Kitchner, Ont., Canada N2G4J6 (519) 744-7111	To develop and build multi-terminal video/graphic information systems for hospitals, financial institutions, and airports.	Undisclosed funds from parent company, Electrohome Ltd.	W. M. Harrold, division manager	Electrohome Ltd., manager, video display sector
EG&G Mound Applied Tech. 15 E. Linden Ave. Miamisburg, OH 45342 (513) 859-3593	To manage the Department of Energy's Mound Facility, which makes mechanical and electrical components for nuclear weapons.	Wholly owned subsidiary of EG&G Inc.	Donald E. Michel, president, general manager	EG&G Electronic Components Div., manager
Innovative Electronics 1600 Pennsylvania Ave. York, PA 17404 (717) 845-8855	To produce carbon film resistors for high-voltage applications such as X-ray machines and lasers.	$100,000 from Ben Franklin Partnership	Marc Brandt, president, founder	Innovative Electric, president, founder
Jade Simulations Intl. 5001 13th Ave. N.W. Calgary, Alta., Canada T3B1J1 (403) 247-1144	To develop and market applications software to run on parallel computers for the military.	$200,000 in first round	Brian Unger, president Greg Kletke, v.p. marketing	Univ. of Calgary, dir., Software Research Group Univ. of Calgary, mgr., Technology Transfer Group
Pictographics Intl. 1601 E. Highway 13 Burnsville, MN 55337 (612) 894-6247	To provide consulting and systems-integration services to businesses using computer graphics.	Undisclosed funds from founder	Wayne Huelskoetter, president, CEO, founder	Dicomed, president, founder
Precision Electronics 1600 Pennsylvania Ave. York, PA 17404 (717) 845-8704	To design, build, and market electronic subassemblies and sensors.	Undisclosed funds from founder	Ash Bhargave, president, founder Ray Lehman, dir. quality assurance	Du Pont Connector Systems, sr. engineer Du Pont Connector Systems, quality engineer
Teledyne MIL 1300 Terra Bella Ave. Mountain View, CA 94039 (415) 968-9241	To provide radiation-tolerant CMOS logic products for the military, aerospace, avionics, and satellite-telecommunications industries.	$3.5 billion from parent company, Teledyne Semiconductor	Mitch Gooze, president, co-founder Lee Arnold, dir. marketing & sales, co-founder	Teledyne Semiconductor, president (current) Teledyne Semiconductor, consultant
Unidyne Training Facilities 5900 Olson Memorial Hwy. Minneapolis, MN 55422 (612) 544-2721	To supply facilities to train athletes; the company is building a swimming treadmill at the U.S. Olympic Training Center in Colorado Springs, Colorado.	Wholly owned subsidiary of FluiDyne Corp.	James T. Dunn, president	FluiDyne, v.p. business development (current)

MERGERS

COMPANY	BUSINESS	COMPANY	BUSINESS	NEW NAME
Diamond Research 9850 Old Creek Rd. Ventura, CA 93001 (805) 649-2209	Performs chemical research and consulting, specializing in imaging materials and processes	Advanced Tech. Resources 6256 Pleasant Valley Rd. El Dorado, CA 95623 (916) 626-4104	Provides patent information and technical analysis for developing nonimpact printers	Not available
Interactive Training Sys. 9 Oak Park Dr. Bedford, MA 01730 (617) 271-0500	Develops interactive videodiscs for corporate training and consumer sales	Spectrum Training 9 Oak Park Dr. Bedford, MA 01730 (617) 271-0500	Supplies custom and off-the-shelf training products, emphasizing sales and sales management	Spectrum Interactive

ACQUISITIONS

BUYER	BUSINESS	COMPANY ACQUIRED	BUSINESS	AMOUNT
Control Data 8100 34th Ave. S. Minneapolis, MN 55440 (612) 853-8100	Markets high-performance computers	Silicon Graphics 2011 Stierlin Rd. Mountain View, CA 94039 (415) 960-1980	Designs and builds advanced workstations	$68.9 million (20 percent interest)
CMS Enhancements 3080-A Airway Ave. Costa Mesa, CA 92626 (714) 549-9111	Makes mass-storage subsystems and expansion boards for personal computers	N. Atlantic Ind.'s tape-drive business, 60 Plant Ave., Hauppauge, NY 11788 (516) 582-6500	Makes quarter-inch-tape drives	$2 million (est.)
Data Technology 2551 Walsh Ave. Santa Clara, CA 95051 (408) 727-8899	Makes controller boards, disk drives, and high-resolution printers	Zentec 2400 Walsh Ave. Santa Clara, CA 95050 (408) 727-7662	Makes computer terminals and microcomputers	$12.6 million (est.)
Data Technology 2551 Walsh Ave. Santa Clara, CA 95051 (408) 727-8899	Makes controller boards, disk drives, and high-resolution printers	Qume 2350 Qume Dr. San Jose, CA 95131 (408) 942-4000	Makes printers, terminals, and related supplies	Not disclosed
Eastman Kodak 343 State St. Rochester, NY 14650 (716) 724-4000	Makes photographic supplies and equipment	Interactive Systems 2401 Colorado Ave. Santa Monica, CA 90404 (213) 453-8649	Develops Unix-based software	Not disclosed
Mentor Graphics 8500 S.W. Creekside Place Beaverton, OR 97005 (503) 626-7000	Makes computer-aided design and engineering workstations	Tektronix's CAE and CASE business Box 500 Beaverton, OR 97077 (503) 627-7111	Makes computer-aided engineering (CAE) and software engineering (CASE) equipment	$5 million
Network Equipment Tech. 400 Penobscot Dr. Redwood City, CA 94063 (415) 366-4400	Makes wide-area networks and networking software	Excelan 2180 Fortune Dr. San Jose, CA 95131 (408) 434-2300	Makes local-area networks	$125 million (est.)
Raychem 300 Constitution Dr. Menlo Park, CA 94025 (415) 361-3333	Makes a wide range of products, including electronic equipment	Sigmaform 2401 Walsh Ave. Santa Clara, CA 95051 (408) 727-6510	Makes telecommunications protective equipment	$43 million
Semiconductor Test Solutions 4101 Burton Dr. Santa Clara, CA 95054 (408) 727-2885	Makes digital-logic semiconductor systems	Axiom Technology 375 Elliot St. Newton, MA 02164 (617) 965-8010	Makes automatic test equipment	Not disclosed
VG Instruments 300 Broad St. Stamford, CT 06901 (203) 329-8050	Makes mass spectrometers, surface analysis, and molecular-process analysis equipment	Kevex 1101 Chess Dr. Foster City, CA 94404 (415) 573-5866	Makes imaging detectors and surface-analysis equipment	$64.8 million

JOINT VENTURES

COMPANY	COMPANY	PURPOSE	CONTACT
Automoted Sconning	Auta-tral Technalagy	Ta canvert technical illustratians, manuals, and publicatians inta computer-readable farmats sa they will wark with Auta-tral's graphic systems.	Autamated Scanning 2530 S. Parker Rd. Aurara, CO 80014 (303) 696-6242
Cylix Communicatians	Compass Computer Services	Ta canvert Campass reservatian systems, which are used by arganizatians such as Budget Rent-a-Car and Hiltan Hatels, to Cylix's satellite-based cammunicatians netwark.	Cylix Cammunications 800 Ridge Lake Blvd. Memphis, TN 38119 (901) 761-1177
Digitol Equipment	DSC Communicotions	Ta develap advanced telecammunicatians-netwark products.	Digital Equipment 146 Main St. Maynard, MA 01754 (800) 344-4825
Generol Electric	IBM	Ta develap camputer chips that IBM will use in future praducts.	GE/RCA Salid State Div. Raute 202 Samerville, NJ 08876 (201) 685-6000
Houstan Lighting & Pawer	ARC Tech	Ta develap a way ta canvert caal inta methane gas using sulfur-eating micrabes.	Haustan Lighting & Pawer Bax 1700 Haustan, TX 77001 (713) 481-7608
Intelligent Technology Group	Storwood	Ta apply Intelligent Technalagy's partfalia-management saftware ta Starwaad's investments an behalf af its clients.	Intelligent Technalagy Graup 115 Evergreen Heights Dr. Pittsburgh, PA 15229 (412) 931-7600
Interleaf	IBM	Ta develap desktap-publishing saftware that will run an IBM camputers.	Interleaf 10 Canal Park Cambridge, MA 02141 (617) 577-9800
Johnsan Cantrals	IllumElex	Ta cambine Jahnsan's cantrals far heating, ventilating, and air-canditianing equipment with IllumElex's lighting praducts and services.	Johnsan Cantrals 8ax 423 Milwaukee, WI 53201 (414) 274-4128
Memtek	Chem-Nucleor Systems and Resaurce Technalagies	Ta pursue and fulfill cantracts ta treat radiaactive graundwater, pracess water, and surface-impaundment water in the United States.	Memtek 28 Cook St. Billerica, MA 01821 (617) 667-2828
NEC Hame Electronics	Enobling Technalagies	Ta develap praducts and explare new technalagies in graphics manipulatian, animatian, and aptical media.	NEC Hame Electranics 1255 Michael Dr. Waad Dale, IL 60191 (312) 860-9500
Pratt & Whitney	Ralls-Royce	Ta study and evaluate an engine that will let supersanic fighter aircraft make shart takeaffs and vertical landings.	Pratt & Whitney Bax 109600 W. Palm Beach, FL 33410 (407) 796-6797
Rocal Telecommunications Graup	Campagnie Finonciere pour lo Rodiatelephone	Ta help establish and aperate an analag cellular-radia service in France.	Racal Telecamm. Graup 122 East 42nd St. New Yark, NY 10168 (212) 687-5040
Scientific Camputer Systems	MacNeol-Schwendler	Ta research and develap saftware far Scientific Camputer System's SCS-40 supercamputer.	Scientific Camputer Systems 10180 Barnes Canyon Rd. San Diega, CA 92121 (619) 546-1212

LEADING 100

COMPANY (SYMBOL/EXCHANGE)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE LAST QUARTER ($)	EARNINGS PER SHARE CHANGE FROM 1 YEAR AGO	LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
AEROSPACE									
TransTechnol. (TT/NYSE)	1/30	14.3	22.00	.61	-18.7	.88	9.4	.72	207.5
Fairchild Ind. (FEN/NYSE)	2/6	11.9	10.50	.11	NE	.20	52.5	2.39	443.2
ARX (ARX/NYSE)	3/13	11.7	8.38	.08	-66.7	—	10.9	.87	74.9
OEA (OEA/AMEX)	4/8	10.3	24.13	.36	.0	—	15.0	.00	42.2
Rohr Ind. (RHR/NYSE)	5/19	8.7	25.00	.44	-6.4	—	17.9	.43	773.2
Prec. Aerotech (PAR/AMEX)	6/29	6.1	4.38	.05	-68.8	—	16.8	.68	35.8
Boeing (BA/NYSE)	7/22	6.0	48.75	.89	17.1	1.60	15.1	.05	15,205.0
Gen. Dynamics (GD/NYSE)	8/23	5.5	55.38	2.52	2.9	1.00	5.4	.27	9,495.6
Sundstrond (SNS/NYSE)	9/27	5.0	52.50	.81	-11.0	1.80	30.0	.47	1,385.5
Motec (MXC/AMEX)	10/3	4.8	5.50	.04	100.0	—	50.0	.22	21.6
CHEMICALS									
Flomemaster (FAME/NASDAQ)	1/8	24.0	3.88	.01	-80.0	—	13.8	.00	5.1
Kinark (KIN/AMEX)	2/10	24.0	3.88	.05	66.7	—	NE	1.08	28.9
Ferro (FOE/NYSE)	3/41	23.4	33.63	.82	67.3	.68	12.8	.25	907.4
Ookite Products (OKT/NYSE)	4/35	20.5	36.00	.72	35.8	1.52	13.7	.07	80.3
Crompt. & Knwl. (CNK/NYSE)	5/19	16.4	31.00	.60	53.8	.92	14.4	.17	245.3
Wellman (WLMN/NASDAQ)	6/52	15.9	31.00	.49	88.5	—	17.9	.40	260.9
Bio-Rod Labs (BIOB/AMEX)	7/49	14.6	20.63	NA	NA	—	NA	NA	NA
Adv. Polymer (APOS/NASDAQ)	8/11	14.5	7.88	-.06	NE	—	NE	.18	2.3
Balchem (BLCC/NASDAQ)	9/18	14.2	5.00	.09	NE	.03	16.1	.19	6.8
WD Forty (WDFC/NASDAQ)	10/30	14.2	32.25	.55	5400.0	1.65	15.1	.00	74.7
COMMUNICATIONS									
Philipp LD Tel. (PHI/AMEX)	1/30	35.7	9.00	.21	-55.3	.15	14.1	2.61	317.9
Millicom (MILL/NASDAQ)	2/5	30.4	18.75	-.31	-100.0	—	NE	.00	14.8
MCI Comm. (MCIC/NASDAQ)	3/37	27.8	14.38	.19	171.4	—	34.2	2.12	4,115.0
VTX Electronics (VTX/AMEX)	4/40	23.5	4.63	.01	-90.0	—	NE	1.27	33.8
Linc Telecom. (LTEC/NASDAQ)	5/27	22.4	35.50	.71	44.9	1.24	13.3	.44	174.0
Century Tel. (CTL/NYSE)	6/25	19.2	29.50	.56	30.2	.88	15.1	1.51	156.9
Telephone Data (TDS/AMEX)	7/12	18.1	28.63	.22	-18.5	.36	37.2	2.01	174.6
Graphic Scanning (GSCC/NASDAQ)	8/15	17.0	8.19	.37	-68.4	—	7.1	1.79	111.8
Phonemate (PHMT/NASDAQ)	9/51	13.3	4.25	-.07	-100.0	—	15.7	13.00	112.3
Comcoa (CCOA/NASDAQ)	10/20	12.5	11.25	.00	NE	—	NE	2.26	14.5
COMPUTERS									
Anderson Jac. (AJ/AMEX)	1/33	66.4	1.88	-.32	NE	—	NE	.00	39.4
AST Research (ASTA/NASDAQ)	2/83	41.5	14.50	.45	55.2	—	16.5	.00	340.2
Terminal Data (TERM/NASDAQ)	3/125	39.1	3.13	.01	NE	—	NE	.35	26.2
Valid Logic (VLID/NASDAQ)	4/128	36.3	5.63	.05	NE	—	NE	.08	66.6
Pyramid Tech. (PYRD/NASDAQ)	5/107	31.7	13.50	.24	380.0	—	23.3	.02	65.9
Amdahl (AMH/AMEX)	6/121	30.9	42.88	.81	58.8	.20	14.1	.13	1,554.4
Infotron Sys. (INFN/NASDAQ)	7/41	29.2	11.63	.17	NE	—	NE	.00	89.3
Atari (ATC/AMEX)	8/163	28.2	8.50	.33	50.0	—	11.2	.00	493.2
Alpha Microsys. (ALMI/NASDAQ)	9/23	27.0	5.88	.16	NE	—	NE	.00	46.0
Micom Sys. (MICS/NASDAQ)	10/51	26.5	16.13	.25	4.2	—	31.0	.03	223.4
DRUG MANUFACTURERS									
Thompson Med. (TM/NYSE)	1/45	50.4	19.00	.60	46.3	.40	14.6	.00	143.9
Bolar Pharm. (BLR/AMEX)	2/41	36.0	29.25	.40	185.7	.03	32.1	.00	95.4
Alco Hlth. (AAHS/NASDAQ)	3/42	23.7	21.50	.43	38.7	.12	13.4	.71	1,921.5
Mylan Labs (MYL/NYSE)	4/73	22.0	11.75	.21	16.7	.10	16.8	.07	96.0
A L Labs (BMD/AMEX)	5/2	11.8	14.25	.22	120.0	.12	19.5	.33	156.7
Cytogen (CYTO/NASDAQ)	6/19	11.0	8.75	-.19	-100.0	—	NE	.00	11.4
MedChm. (MCH/AMEX)	7/48	10.5	13.13	.15	7.1	—	23.9	.01	10.1
Appld. Biosci. (APBI/NASDAQ)	8/17	10.2	16.25	.28	40.0	—	16.4	4.66	36.9
Synergen (SYGN/NASDAQ)	9/79	10.1	6.75	-.12	-100.0	—	NE	.12	6.2
Erbamont (ERB/NYSE)	10/84	9.7	24.00	1.27	108.2	.60	9.3	.28	971.4

The HIGH TECHNOLOGY BUSINESS Leading 100 lists the 10 companies in each of 10 industries that had the highest stock gain over the previous month (figures as of 5/5/88).

NA Not available NE Negative earnings NC Not calculable NM — No meaningful figure

COMPANY (SYMBOL/EXCHANGE)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE LAST QUARTER ($)	EARNINGS PER SHARE CHANGE FROM 1 YEAR AGO	LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
ELECTRONICS									
Cushman Elec. (CUSH/DTC)	1/12	150.0	1.25	.09	NE	—	NE	.00	6.2
RMS Intl. (RMS/AMEX)	2/221	53.4	2.50	.06	NE	—	NE	.50	12.6
Oyansen (DYAN/NASDAQ)	3/2	51.5	2.94	.05	66.7	—	12.2	.35	25.9
Tekelec (TKLC/NASDAQ)	4/16	50.0	12.00	.28	1,300.0	—	26.1	.00	20.1
Elexis (ELEX/NASDAQ)	5/213	46.3	2.75	-1.14	-100.0	—	NE	.06	7.5
IEC Elec. (IECE/NASDAQ)	6/194	45.3	10.00	.18	5.9	.20	15.2	.13	25.6
Vicon Ind. (VII/AMEX)	7/203	44.8	6.88	.13	550.0	—	23.7	.82	43.1
Margaux (MRGX/NASDAQ)	8/151	40.5	2.81	.09	NE	—	NE	.23	17.9
Microwave Filter (MFCD/NASDAQ)	9/246	38.0	1.38	.01	.0	—	10.6	.32	4.6
La Pointe Ind. (LPI/AMEX)	10/244	36.6	3.25	.05	NE	—	NE	.35	4.3
HEALTH									
Meridian Diag. (KITS/NASDAQ)	1/81	36.6	3.25	.03	.0	—	32.5	.04	5.5
Biosearch Med. (BMPI/NASDAQ)	2/112	32.7	1.50	-.13	NE	—	NE	6.83	18.3
Gish Biomed. (GISH/NASDAQ)	3/91	32.4	6.13	.11	22.2	—	16.6	.10	11.2
Camb. Med. Tech. (CMTC/DTC)	4/54	30.7	2.13	-.06	NE	—	NE	1.26	3.3
Oncogene Sci. (ONCS/NASDAQ)	5/92	27.8	4.00	-.02	-100.0	—	NM	.00	5.3
Aequitron Med. (AQTN/NASDAQ)	6/114	26.0	3.63	.10	NE	—	NE	.26	21.3
Novametrix (NMTX/NASDAQ)	7/90	25.2	9.00	.06	100.0	—	64.3	.16	19.5
Everest & Jenn. (EJA/AMEX)	8/17	23.9	11.00	NA	NA	.20	NA	NA	NA
Amserv (AMSR/NASDAQ)	9/36	23.5	2.63	.08	NE	—	NE	5.67	5.8
Delmed (DMD/AMEX)	10/95	23.5	1.00	-.01	NE	—	NE	55.25	25.4
METALS FABRICATION									
Met-Coil Sys. (METS/NASDAQ)	1/17	27.9	6.88	.24	242.9	.12	14.3	.64	48.7
Clabir (CLGBB/NASDAQ)	2/15	22.7	2.00	NA	NA	.16	NA	NA	NA
Columbia Gen. (CLGN/DTC)	3/3	20.0	6.00	.15	-44.4	—	3.1	.42	54.1
Edgecomb (EDGC/NASDAQ)	4/1	14.2	5.00	.00	NE	—	62.5	18.54	555.5
RB&W (RBW/AMEX)	5/39	14.2	5.00	.15	650.0	—	NE	.81	175.9
Allegheny Lud. (ALS/NYSE)	6/41	13.5	27.25	.90	21.6	.30	11.2	.40	935.5
Synalloy (SYD/AMEX)	7/29	13.3	4.25	.20	400.0	—	21.3	.20	54.8
Trinity Ind. (TRN/NYSE)	8/7	12.0	33.88	.26	271.4	.50	80.7	1.28	583.8
Cyclops Ind. (CYC/NYSE)	9/38	11.6	27.63	NA	NA	—	NA	NA	NA
Material Sci. (MSC/AMEX)	10/6	10.1	19.13	.35	169.2	—	17.4	.74	152.3
SCIENTIFIC AND ELECTRONIC INSTRUMENTS									
Laser Photo (LAZR/DTC)	1/4	44.2	1.63	-.02	NE	—	NE	1.45	4.6
Bear Auto Svc. (BEAR/NASDAQ)	2/2	41.7	8.50	.07	16.7	—	NE	.63	94.9
Tinsley Labs (TNSL/DTC)	3/80	35.0	6.75	-.09	NE	—	NE	.31	6.3
EIL Inst. (EILI/NASDAQ)	4/11	34.8	7.25	.06	200.0	—	30.2	.77	54.9
Data Trans. (DATX/NASDAQ)	5/38	32.6	14.25	.17	-5.6	—	15.8	.00	32.3
Photronics (PHOT/NASDAQ)	6/71	23.5	5.25	.13	-23.5	—	7.2	.73	14.3
Electro. Sensors (ELSE/NASDAQ)	7/9	22.9	3.38	.06	-25.0	.10	10.9	.00	4.3
Acusan (ACSN/NASDAQ)	8/47	22.7	27.00	.25	78.6	—	32.1	.00	119.9
Edison Control (EDCD/NASDAQ)	9/97	22.2	2.75	.01	-93.3	—	30.6	.00	1.8
Modern Controls (MDCD/NASDAQ)	10/61	20.7	8.00	.18	63.6	.10	13.1	.02	7.1
SOFTWARE AND DATA PROCESSING									
Worldo Data (WDSI/NASDAQ)	1/4	80.0	2.25	-.06	-100.0	—	NE	.60	11.4
Algorex (ALGO/NASDAQ)	2/3	53.2	2.88	-.09	NE	—	NE	1.40	6.4
Keane Assoc. (KEAN/NASDAQ)	3/66	47.1	12.50	.46	130.0	—	13.9	.19	47.1
Mgmt. Sci. Amer. (MSAI/NASDAQ)	4/141	39.7	8.38	.14	NE	—	19.5	.02	274.9
Symbolics (SMBX/NASDAQ)	5/71	33.6	1.75	-.37	NE	—	NE	.02	101.6
Penta Sys. Intl. (PSLI/DTC)	6/143	32.7	1.50	.02	NE	—	NE	.13	22.0
Daisy Sys. (DAZY/NASDAQ)	7/111	28.7	9.50	.07	NE	—	NE	.00	108.3
ISI Sys. (SYS/AMEX)	8/65	25.3	14.88	.23	21.1	.24	19.1	.08	35.9
Mentor Graphics (MENT/NASDAQ)	9/112	24.0	32.25	.40	60.0	—	23.9	.00	238.9
Avant Garde (AVGA/NASDAQ)	10/140	22.7	2.00	-.07	NE	—	NE	.01	17.4

SOURCE: MEDIA GENERAL FINANCIAL SERVICE

COMPANY INDEX

The following is a list of companies mentioned in this issue and the pages on which they appear. Companies in Marketwatch, the High Technology Business Leading 100, and Newsletter Digest are not included.

BUSINESS/TECHNOLOGY CENTER

SAMPLE AD

YOUR

LOGO

HERE

To place your 1/9 ad in this section, send us a photo of your product or your logo. Include your copy of no more than 200 characters and a heading of no more than 14 characters.

To place an ad, *call Jennifer Battikha, High Technology Business* magazine, (617) 723-6611.

Place your ad in this space . . . and reach nearly 170,000 upscale, corporate decision-makers for one full month.

Business/Technology Center lets you:

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- test new markets
- receive valuable leads
- distribute product information
- offer free samples

Business/Technology Center

To reach corporate decision-makers who ACTIVELY pursue business information in all areas of high technology, there is NO OTHER place to go but *High Technology Business* magazine. Inquiries about the ads in *High Technology Business* magazine skyrocketed 160 percent from September to October 1987.

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Business/Technology Center

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1X $1,500	3X $1,300
6X $1,100	12X $900

GET VALUABLE LEADS

By advertising in the Business/Technology Center, you'll gain important information on prospective clients by receiving a free circle number.

To place an ad, contact *Jennifer Battikha* at *High Technology Business* magazine, 214 Lewis Wharf, Boston, MA 02110, or call (617) 723-6611.

Reach nearly 170,000 upscale, corporate decision-makers for one full month. Place your 1/9 ad in the Business/Technology Center by following these easy steps:

1. Send us a black-and-white photo of your product, or a copy of your logo.
2. Include copy of no more than 200 characters and a heading of no more than 14 characters.
3. Fill in the form below. We do the rest!

- ***Your company will be given a FREE circle number to receive valuable leads.***

Send this form with materials to Business/Technology Center, Jennifer Battikha, *High Technology Business* magazine, 214 Lewis Wharf, Boston, MA 02110, or call (617) 723-6611.

Name _____

Company _____

Address _____ City _____

State _____ Zip _____ Phone _____

Sound Ideas for Home, Car

HOME

The walls are alive with music

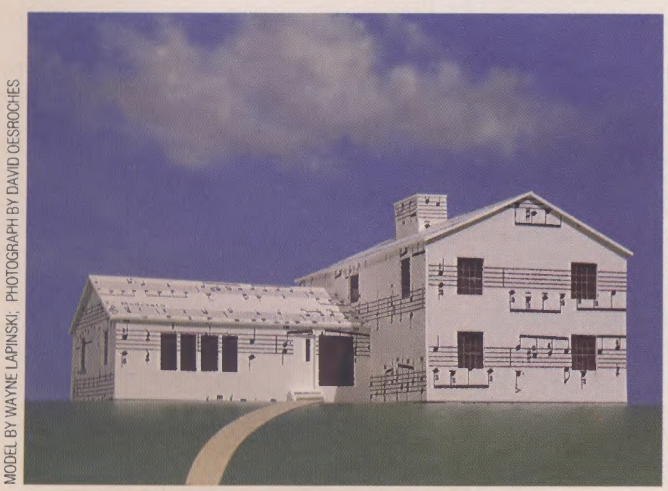
MUSIC LOVERS who are building new homes can now plan their musical environment along with the plumbing and electrical wiring. The Bose Acoustimass system includes software that lets builders design home sound systems based on the acoustic properties of their particular structure.

The software runs on an Apple Macintosh computer. Acoustimass hardware includes a patented speaker that hides in a floor, wall, or ceiling. Smaller speakers are recessed in walls or ceilings, and sub-woofers—ultra-low-frequency speakers that create rumbles—get tucked inside furniture or behind curtains. The wires and control units go behind the walls, and each room winds up with its own volume and power controls.

The Acoustimass system includes a wall-mounted music center with a compact-disc player, but works with almost any music source, including radios and turntables. The cost of a four-room system ranges from $4,500 to $6,000.

The Acoustimass system is available through NuTone dealers. Bose Corp.'s address is The Mountain, Framingham, MA 01701. Telephone (617) 879-7330.

—Jennifer Christensen



MODEL BY WAYNE LAPINSKI; PHOTOGRAPH BY DAVID DESROCHES

Bose's Acoustimass music system becomes part of the floor plan.

AUTO

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The computer synchronizes its internal odometer to a vehicle's odometer by sensing the impulses of magnets that the user attaches to the drive shaft. The system prints out travel information on a small printer. Both computer and printer measure 7×4×1½ inches and draw their power from the vehicle's battery.

Drivers can request a printout at the end of each trip, or make as many as 60 trips before getting the data on paper.

The Odometer Data Computer costs $399; an advanced version with a security system and the ability to encode data is $499. The product can pay for itself by easing record-keeping, says Carol Allred, president of Mileage Validator.

Mileage Validator Inc. is located at 1799 North Graves, McKinney, TX 75069. Phone (214) 548-9691.

—Kenan Woods

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THE PRODIGY on-line service won't make you a genius, but it will let you bank, shop for groceries, and make travel plans without leaving the house. The electronic information service works with IBM PC-compatible computers that have at least 512 kilobytes of memory, and its monthly subscription fee is only $9.95.

MICHAEL SIMPSON

Prodigy is based on local minicomputers, which subscribers call and connect to using a modem linked to their personal computer. Subscribers then have access to various Prodigy services, which range from securities trading to electronic mail. One service, called "Ask the Experts," lets subscribers ask questions and receive personal responses from a panel of celebrity-experts, including Sylvia Porter on finance, Howard Cosell on sports, and Jane Fonda on exercise.

The Prodigy service will be introduced this year in Atlanta, San Francisco, and Hartford, Conn., and expects to go nationwide by 1990. The company is developing versions for the Apple II and Macintosh computers.

For more information, contact Prodigy Services Co., 445 Hamilton Ave., White Plains, NY 10601. Telephone (914) 993-8000.

—Elizabeth Aaron

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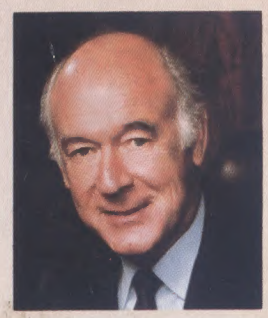

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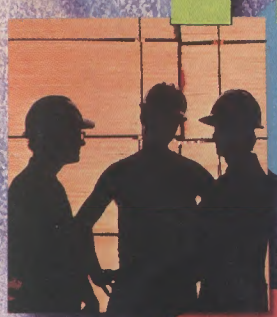

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